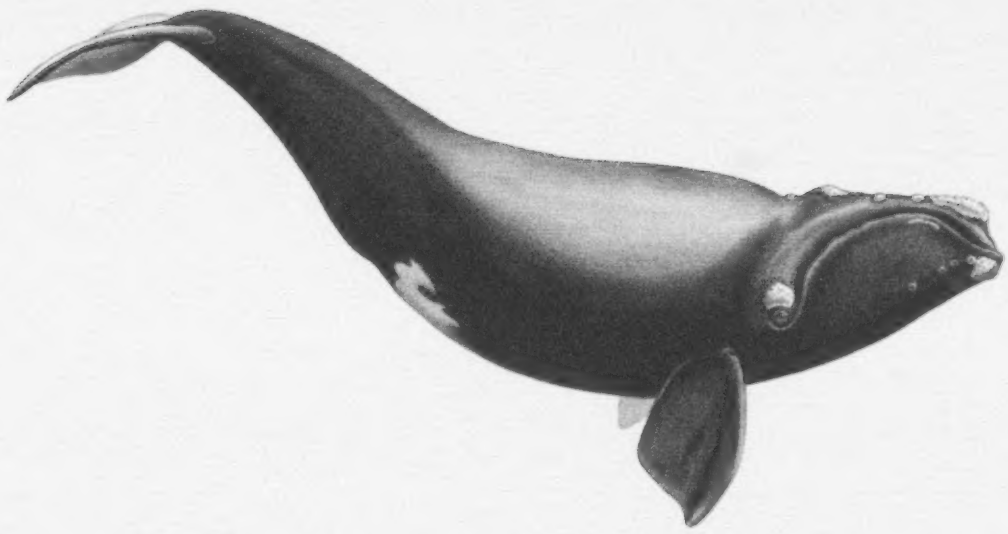
COSEWIC
Assessment and Status Report

on the

North Atlantic Right Whale
Eubalaena glacialis

in Canada



ENDANGERED
2013

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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Previous report(s):

COSEWIC. 2003. COSEWIC assessment and update status report on the North Atlantic right whale *Eubalaena glacialis* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 28 pp.

Gaskin, D.E. 1990. Update COSEWIC status report on the North Atlantic right whale *Eubalaena glacialis* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 25 pp.

Gaskin, D.E. 1985. Update COSEWIC status report on the right whale *Eubalaena glacialis* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 50 pp.

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COSEWIC
Assessment Summary

Assessment Summary – November 2013

Common name
North Atlantic Right Whale

Scientific name
Eubalaena glacialis

Status
Endangered

Reason for designation
This long-lived, slowly reproducing whale species was driven nearly to extinction by commercial whaling but has been protected from whaling since 1935. The whales found in Canada are part of a single global population of the species, which is endemic to the North Atlantic Ocean. Since 1990, the total population has been increasing at a rate of approximately 2.4% per year. The total population in 2010, including all age classes, was estimated at 468 individuals, of which between 122 and 136 were adult females. The estimated number of mature individuals, after accounting for a male-biased sex ratio among adults, and for a small number of females that are incapable of reproducing, is between 245 and 272. The rate of population growth is lower than would be predicted based on the biology of the species and is limited by ship strikes and entanglements in fishing gear. Although measures have been implemented in both Canada and the United States to lessen ship strikes, they continue to occur and ship traffic is expected to increase significantly within the range of the species in coming decades. Further, adult females appear to be more prone to being struck than males. Limited efforts have also been made to reduce the incidence and severity of entanglements, but these events remain a major cause of injury and mortality.

Occurrence
Atlantic Ocean

Status history
The Right Whale was considered a single species and designated Endangered in 1980. Status re-examined and confirmed in April 1985 and in April 1990. Split into two species in May 2003 to allow a separate designation of the North Atlantic Right Whale. North Atlantic Right Whale was designated Endangered in May 2003 and November 2013.

COSEWIC
Executive Summary

North Atlantic Right Whale
Eubalaena glacialis

Wildlife Species Description and Significance

North Atlantic Right Whales (*Eubalaena glacialis*) are large baleen whales that measure ~14 m (± 0.15 SD) and weigh ~30 mt (± 5.4 SD) at maximum size according to standard growth models fitted using necropsy and photogrammetry data. However, Right Whales can reach lengths up to 18 m. Females are ~0.7 m longer than males when sexually mature. Right Whales appear stocky, with broad paddle-like flippers, a large head (~1/4 of their body length) and no dorsal fin. Their wide flukes have a smooth trailing edge separated by a pronounced notch. Most of their body is black although some animals have white on their chin and belly. Large patches of raised epithelial tissue (callosities) are present on the head and chin, above the eyes, behind the blowholes and along the lower lip.

Distribution

In the western North Atlantic, Right Whales range from Florida to Newfoundland and the Gulf of St. Lawrence. A portion of the population (mainly reproductively mature females, calves and some juveniles) migrates each year from the winter calving grounds off Florida and Georgia (USA) to Canada. About two-thirds of the population typically congregates in the lower Bay of Fundy and on the Scotian Shelf during summer and fall, and small numbers occur in two areas of the Gulf of St. Lawrence—one north and east of the Gaspé Peninsula, and the other southeast of the Gaspé Peninsula in the mouth of Chaleur Bay (Baie-des-Chaleurs).

Habitat

North Atlantic Right Whales occupy a wide range of depths and distances from shore—shallow coastal waters, deep coastal waters and offshore waters. Pregnant and lactating females frequent shallow warm coastal waters off Florida and Georgia from about November to April, and animals use colder and more productive habitat to the north (e.g., Cape Cod Bay) from January to mid-May. All demographic groups forage in the Great South Channel in spring and early summer, and in deep coastal areas such as the Bay of Fundy and Scotian Shelf from summer to late fall. North Atlantic Right Whales depend on environmental and oceanic processes (e.g., wind, temperature, salinity, and currents) to concentrate dense patches of copepods for feeding. Thus, variability in these parameters can alter the quality of their habitat.

Biology

North Atlantic Right Whales are filter feeders that eat primarily calanoid copepods and occasionally euphausiids and barnacle larvae. They feed on a variety of copepod species during winter, and on the oil-rich developmental stages of *Calanus finmarchicus* during spring, summer and fall.

Most reproductively mature females give birth to a single calf every 3-5 years. The age of first observed birth has ranged from 5-21 years (mean = 10 years), and at least two females have continued to produce calves during 31 years of observation. The age of first reproduction for males is ~15 years. Generation time (the average age of females with calves) was 16.1 years for the growing population from 2002 to 2009, but may have been as high as 35.7 years pre-exploitation. Generation time is thus between 16 and 36 years.

Right whales breed in courtship groups consisting of one female and multiple males. A birth interval of 3-5 years results in roughly one ovulating female to every four adult males, and leads to significant competition among males for mating opportunities. Gestation is believed to be ~12 months. Calves are typically nursed for one year and attain ~75% of their adult size by the time they wean. Some recognizable individuals have been seen for more than three decades, and the oldest individual on record is believed to have reached an age of at least 70 years old.

Population Size and Trends

A total of 468 individual Right Whales, consisting of 19 first-year calves and 449 non-calves (ages 1+ years), were known or presumed to be alive in 2010. Of the 449 non-calves, 49% were males, 35% females, and 17% of unknown sex. The total adult population in 2010 was likely between 305 and 325 individuals. The estimated number of mature individuals (adjusted for nulliparous females and for the male-biased sex ratio) was between 245 and 272. The mean rate of population growth from 1990 to 2007 was 2.4% per year. The population increased by about 50% between 1990 and 2010, and age structure remained fairly constant. Numbers of calves seen during aerial and boat-based surveys (1993-2010) ranged from 1 to 39 per year.

Threats and Limiting Factors

Mortality from ship strikes and entanglement in fishing gear has limited population recovery. The habitat of North Atlantic Right Whales has considerable vessel traffic and high densities of fishing gear. Other factors that may limit population growth are poorly understood.

Protection, Status, and Ranks

The western stock of North Atlantic Right Whales was severely depleted by whaling that began in the 1600s and continued until the species was legally protected in the 1930s. The species is red-listed as Endangered by IUCN and also listed as Endangered under the U.S. *Endangered Species Act*. In Canada, Right Whales are protected under the Marine Mammal Regulations of the *Fisheries Act*. North Atlantic Right Whales were designated as Endangered in 2005 under the *Species at Risk Act* (SARA) after being assessed by COSEWIC in 2003. In November 2013, COSEWIC re-assessed the status of this species as Endangered.

TECHNICAL SUMMARY

Eubalaena glacialis

North Atlantic Right Whale — Baleine noire de l'Atlantique Nord (Baleine franche)

Range of occurrence in Canada: Atlantic Ocean (off Nova Scotia, Quebec, New Brunswick, Prince Edward Island, and Newfoundland and Labrador)

Demographic Information

Generation time Average age of known females with calves identified from 2002 to 2009 (16.1 y ± 1.54 SD, range 13.1-18.4 years); but may have been as high as 35.7 y pre-exploitation based on population modelling.	16.1 – 35.7 y
Is there an observed continuing decline in number of mature individuals?	No
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	No decline occurring
Observed percent increase in total number of mature individuals over the last 10 years.	Assuming the proportion of mature individuals has remained constant over time, the total number of mature individuals increased by ~24% over 10 years (2001-2010) and ~57% over 20 years (1991-2010)
Projected or suspected percent increase in total number of mature individuals over the next 10 years, or 3 generations.	Unknown
Observed percent increase in total number of mature individuals over any 10 years period, including both the past and the future.	~24% increase over past 10 years (2001-2010) and ~57% increase over past 20 years (1991-2010)
Are the causes of the decline clearly reversible and understood and ceased?	No decline is occurring, but population growth would have been greater in the absence of human-caused mortality
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence within Canadian Jurisdiction	~1.8 million km²
Index of area of occupancy (IAO) See text for alternatives. The following values apply to legally designated critical habitat besides the calving ground in the SE United States: Bay of Fundy 924 km² Roseway Basin 3648 km² Cape Cod Bay 1984 km² Great South Channel 9264 km²	7092 km² consisting of the calving grounds only (in southeastern United States)

Is the total population severely fragmented?	No
Number of locations*	Not applicable
Is there a continuing decline in extent of occurrence?	No
Is there a continuing decline in index of area of occupancy?	No
Is there a continuing decline in number of populations?	No
Is there a continuing decline in number of locations*?	No
Is there a continuing decline in [area, extent and/or quality] of habitat?	Quality likely declining
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations*?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	N Mature Individuals
Western North Atlantic [This estimate assumes a minimum population size of 449 non-calves in 2010 and is based on doubling the number of females believed to have been alive and to have had at least one calf in their lifetimes]	245-272
Eastern North Atlantic [A remnant population may still exist]	Unknown, but if it exists, too small to be of consequence

Quantitative Analysis

Probability of extinction in the wild within 20 years or 5 generations, or within 100 years.	Unknown

Threats (actual or imminent, to populations or habitats)

Actual anthropogenic causes of mortality include vessel strikes and entanglement in fishing gear. Potential threats or limiting factors include noise pollution, chemical pollution, parasites, and habitat degradation.

Rescue Effect (immigration from outside Canada)

Status of outside population? The species consists of a single trans-boundary population that moves seasonally between Canada and the United States. It is listed as Endangered in the United States. There may be a very small remnant population in the eastern North Atlantic.	
Is immigration known or possible?	Unlikely
Would immigrants be adapted to survive in Canada?	Probably
Is there sufficient habitat for immigrants in Canada?	Unknown
Is rescue from outside populations likely?	No

* See Definitions and Abbreviations on COSEWIC website and IUCN 2010 for more information on this term.

Status History

COSEWIC: The Right Whale was considered a single species and designated Endangered in 1980. Status re-examined and confirmed in April 1985 and in April 1990. Split into two species in May 2003 to allow a separate designation of the North Atlantic Right Whale. North Atlantic Right Whale was designated Endangered in May 2003 and November 2013.

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Endangered	D1
Reasons for designation: This long-lived, slowly reproducing whale species was driven nearly to extinction by commercial whaling but has been protected from whaling since 1935. The whales found in Canada are part of a single global population of the species, which is endemic to the North Atlantic Ocean. Since 1990, the total population has been increasing at a rate of approximately 2.4% per year. The total population in 2010, including all age classes, was estimated at 468 individuals, of which between 122 and 136 were adult females. The estimated number of mature individuals, after accounting for a male-biased sex ratio among adults, and for a small number of females that are incapable of reproducing, is between 245 and 272. The rate of population growth is lower than would be predicted based on the biology of the species and is limited by ship strikes and entanglements in fishing gear. Although measures have been implemented in both Canada and the United States to lessen ship strikes, they continue to occur and ship traffic is expected to increase significantly within the range of the species in coming decades. Further, adult females appear to be more prone to being struck than males. Limited efforts have also been made to reduce the incidence and severity of entanglements, but these events remain a major cause of injury and mortality.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. No decline over last three generations and no projected decline over next three generations.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. Extent of occurrence and index of area of occupancy are too large.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. No continuing decline.
Criterion D (Very Small or Restricted Total Population): Meets Endangered D1, with an estimated 245-272 mature individuals.
Criterion E (Quantitative Analysis): No applicable analyses conducted.

PREFACE

The Endangered status of North Atlantic Right Whales was reaffirmed by COSEWIC in 2003. New management measures intended to reduce mortality caused by ship strikes in Canadian and U.S. waters and entanglements in fishing gear in U.S. waters have been implemented since the last assessment. However, deaths and serious injuries from ship strike and entanglement continue to occur.

The number of animals presumed to be alive has increased considerably since the last assessment, with no major change in the age or sex structure/composition of the population. The estimated total population increased from 1990 to 2007 by ~2.4% per year. The estimated total number of whales in the population in 2010 was 468 (all ages including 19 calves born that year) and the estimated number of mature individuals, after accounting for adults considered incapable of reproduction and for the observed male-biased sex ratio, was between 245 and 272.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2013)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

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The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

on the

North Atlantic Right Whale

Eubalaena glacialis

in Canada

2013

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Globally, there are three recognized species of Right Whales—*E. glacialis* in the North Atlantic, *E. australis* in the southern hemisphere, and *E. japonica* in the North Pacific (Rosenbaum *et al.* 2000; IWC 2001b; Perrin 2013). Two of the three species of Right Whales occur in Canadian waters, *E. japonica* in the Pacific and *E. glacialis* in the Atlantic. No subspecies are recognized (Perrin 2013). This report considers the status of *E. glacialis*—the North Atlantic Right Whale. The two French common names used in Canada are Baleine noire and Baleine franche.

Morphological Description

North Atlantic Right Whales are large baleen whales that measure ~14 m (± 0.15 SD) and weigh ~30 mt (± 5.4 SD) at maximum size according to standard growth models fitted using necropsy and photogrammetry data (Fortune *et al.* 2012). However, Right Whales can reach lengths up to 18 m (Reeves and Kenney 2003). They are slightly dimorphic with females ~0.7 m longer than males. They appear stocky with paddle-like flippers and a large head (Fig. 1). A thick blubber layer (8-22 cm) provides insulation and serves as an energy store (Miller *et al.* 2011). Most of the body is black although some animals have white pigmentation on their chin and ventral surface. They have no dorsal fin and no grooves on the throat. Right Whales have large flukes with smooth trailing edges that range in width from ~3 to 5 m.

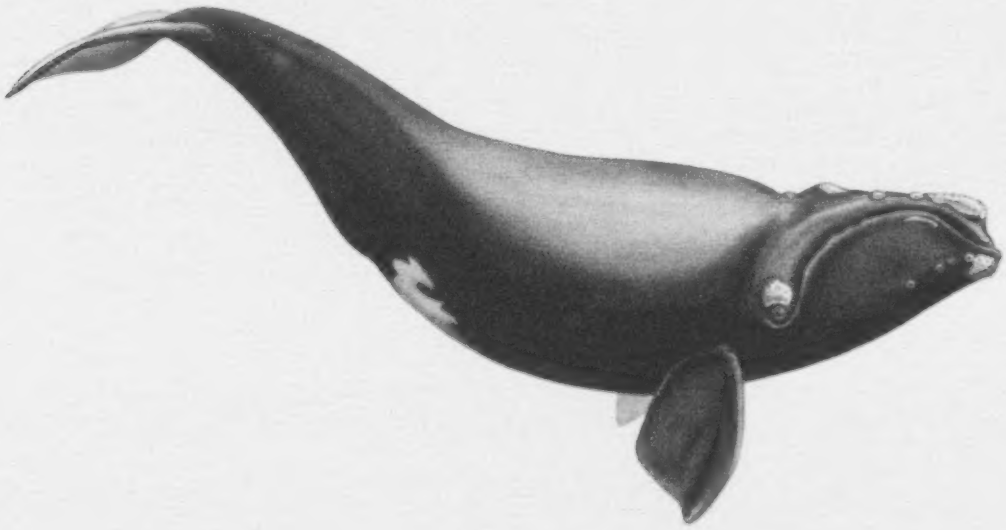

Figure 1. North Atlantic Right Whale (illustration provided by Scott Landry, Provincetown Center for Coastal Studies).

Each Right Whale has a unique pattern of callosities (raised patches of epithelial tissue) on the rostrum behind the blowholes, over the eyes, on the corners of the chin, and sometimes along the lower lips and jaws (Fig. 1). Callosity patterns persist over time and can be used along with body scarring to identify individuals (Payne *et al.* 1983; Kraus *et al.* 1986a; Crone and Kraus 1990; Hamilton and Martin 1999).

The V-shaped blow of a Right Whale can reach 5 m high and is one of the distinguishing features of the species at sea. Right Whales feed at depth or near the surface. When skim feeding, they swim along the surface using the strongly arched, narrow rostrum and bowed lower jaws which are especially suited to this method of feeding. They have ~250 plates of black or brown baleen rooted in the upper jaw. Their baleen plates are long (2.0 to 2.8 m) and narrow (up to 18 cm wide) with fine hair-like fringes along the inner edges of each plate.

Population Spatial Structure and Variability

North Atlantic Right Whales range from Florida to Newfoundland and the Gulf of St. Lawrence (Fig. 2). Winter calving grounds (designated Critical Habitat) are located in the coastal waters of Florida and Georgia (Fig. 3). Whales that use the calving grounds during early winter migrate north in late winter and spring to feed in Cape Cod Bay, the Great South Channel, and Massachusetts Bay (Fig. 3) (Kraus *et al.* 1986b; Winn *et al.* 1986; Kenney *et al.* 2001). Not all known individuals (particularly adult males) occupy these areas during winter. Adult males are generally not seen on the calving grounds or in Cape Cod Bay during winter and their whereabouts at this time are largely unknown (Brown *et al.* 2001; Frasier *et al.* 2007a)

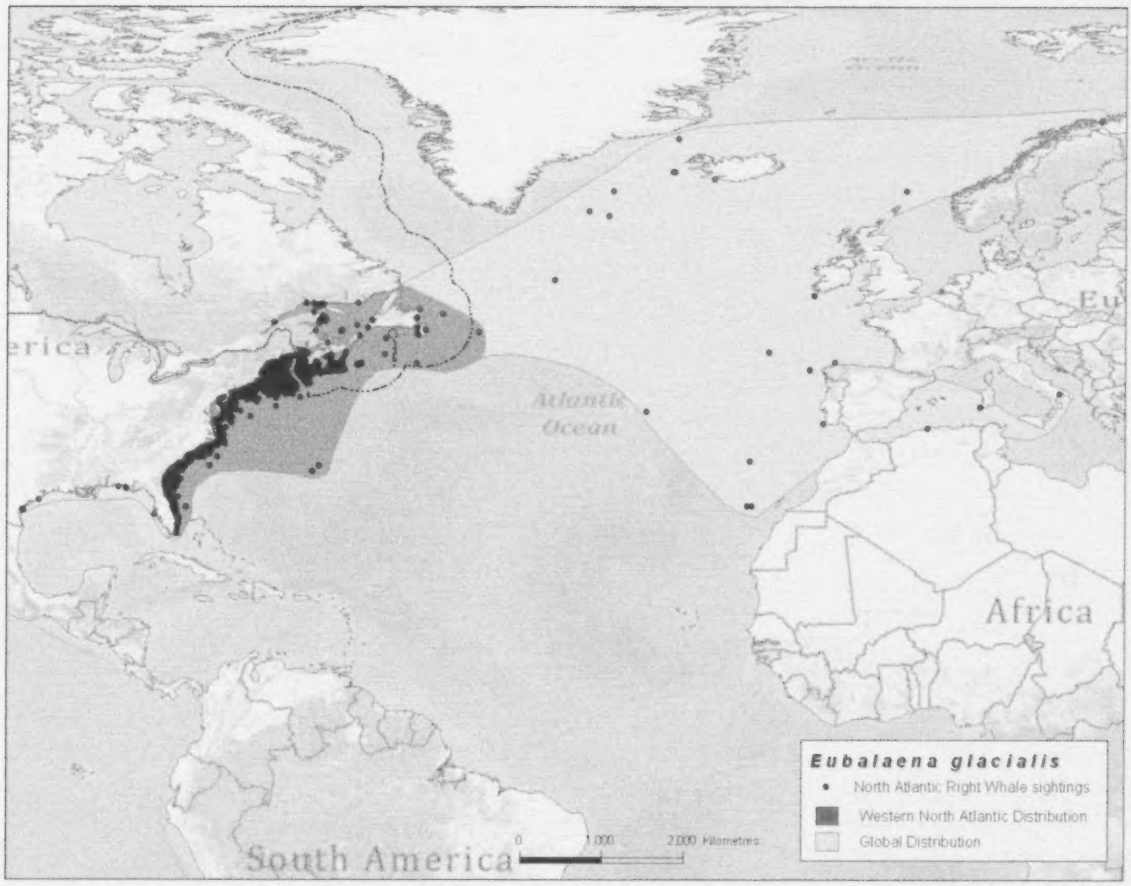

Figure 2. Sightings (black dots,1849-2010) and inferred basin-wide distribution (shaded areas) of Right Whales in the North Atlantic. Sightings data are from the North Atlantic Right Whale Consortium database (Right Whale Consortium 2011) and were not effort-corrected or peer-reviewed. Distributional patterns based on these data are biased by where and when systematic and opportunistic aerial and boat-based observations have been made. Each dot represents a sighting event, which may represent more than one individual whale.

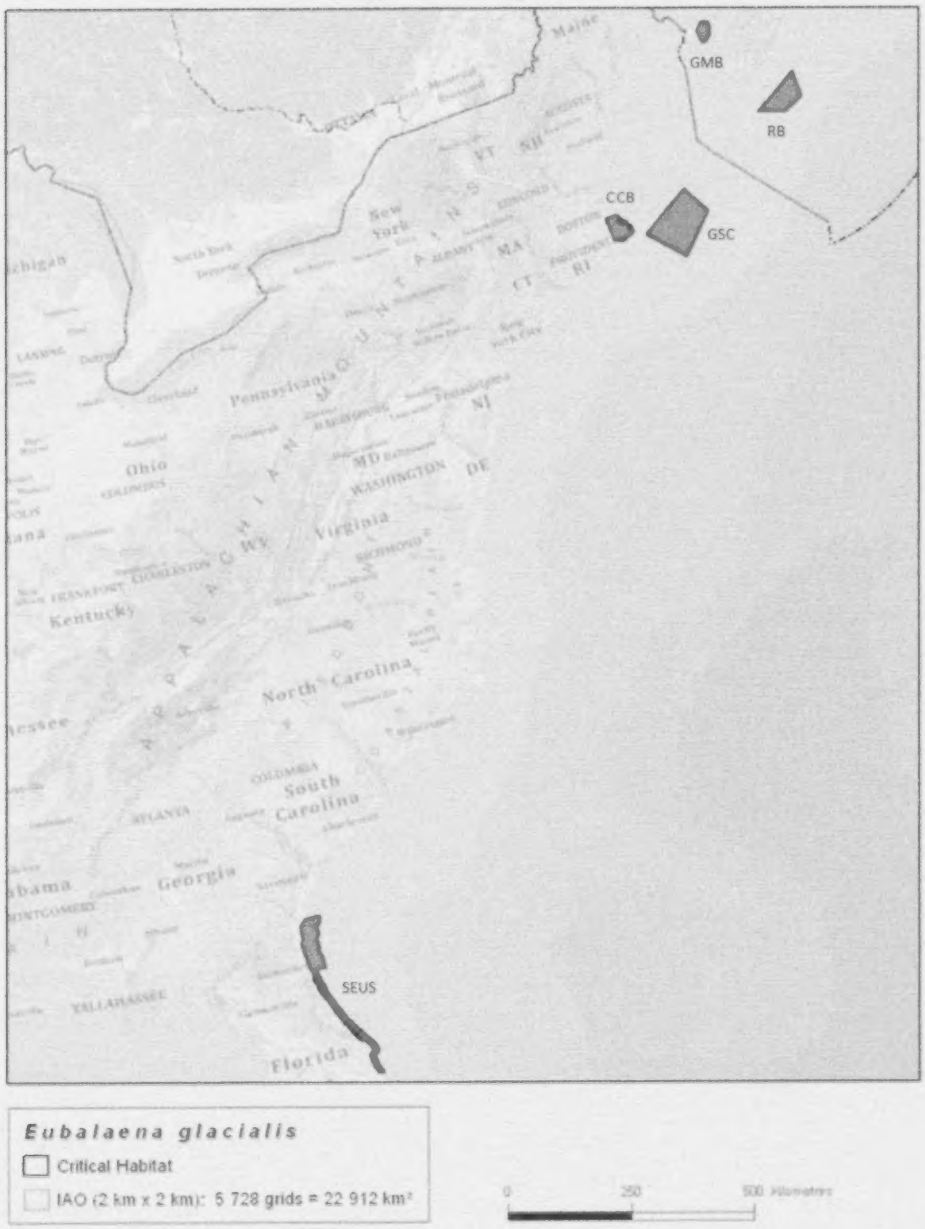

Figure 3. Areas legally identified (Canada) or designated (U.S.) as Right Whale Critical Habitat: Cape Cod Bay (CCB), Great South Channel (GSC) and the calving grounds located in the Southeastern United States (SEUS, from Florida to Georgia) under the U.S. Endangered Species Act and Roseway Basin (RB) and Grand Manan Basin (GMB) under the *Species at Risk Act*.

In summer and fall, Right Whales congregate and feed in the lower Bay of Fundy (mainly east of Grand Manan Island) and in Roseway Basin between Browns and Baccaro Banks on the western Scotian Shelf (Figs. 3 and 4). Smaller numbers occur in summer and fall elsewhere on the Scotian Shelf and in the Gulf of St. Lawrence, mainly along the lower North Shore and south and east of the Gaspé Peninsula in the mouth of Chaleur Bay (Baie-des-Chaleurs). A probable breeding ground located in the middle of the Gulf of Maine was recently discovered (Cole *et al.* 2013). Right Whales have also been sighted sporadically in Denmark Strait, near Iceland, and in Norway, the Azores, Bermuda, and the Gulf of Mexico (Braham and Rice 1984; Mead 1986; Jacobsen *et al.* 2004; Mellinger *et al.* 2011; Silva *et al.* 2012).

Right Whales appear to segregate by age, sex and reproductive state. Probabilities of sighting adult females in some areas off Canada and the United States are lower in inter-birth years compared to years when they give birth (Brown *et al.* 2001). Females with calves often return to the same summer nursery ground. This strong site fidelity may influence where independent offspring return to feed, resulting in different lineages using specific summer habitats (Rastogi *et al.* 2004).

There are no geographic barriers that would create or support genetic structure or strong demographic isolation. DNA extracted from baleen and bone from museum specimens suggests that Right Whales in the eastern and western North Atlantic were not genetically distinct (Rosenbaum *et al.* 2000). Sightings of western North Atlantic Right Whales in the eastern North Atlantic suggest that interbreeding is possible (Silva *et al.* 2012); however, there has been no sign of recovery of Right Whales in the eastern North Atlantic since whaling stopped (Braham and Rice 1984) nor has there been any indication of recolonization by animals from the western Atlantic.

Designatable Units

There is no reason to recognize more than one designatable unit for North Atlantic Right Whales in Canada.

Special Significance

A large proportion of the known range of the species is in Canadian waters. Historically (1630s – early 1900s), Right Whales were of great economic importance for their oil and baleen (Reeves *et al.* 2007). Today, protected from commercial whaling, their economic value in Canada comes from whale-watching tourism in New Brunswick and Nova Scotia. Right Whales are among the most studied marine mammals in the world, and have an interesting reproductive strategy that involves intense sperm competition (Frasier *et al.* 2007a). Organizations and agencies concerned with endangered species and marine conservation have drawn public attention to the plight of Right Whales, which has led to regulatory actions in both the United States and Canada to protect the animals from ship strikes and in the United States from entanglements in fishing gear.

DISTRIBUTION

Global Range

Historically North Atlantic Right Whales occurred throughout much of the North Atlantic, but not in Arctic or tropical waters. Their range included the waters of the Gulf of St. Lawrence and Atlantic Canada (to Labrador), east to southern Greenland, Iceland, and Norway, and south along the European coast to northwestern Africa (Schevill and Moore 1983; Braham and Rice 1984; Brown 1986; IWC 1986; Mead 1986; Mitchell *et al.* 1986). They are now rare or absent in most of the eastern part of the range where they were once relatively common, including northwest Africa, the Bay of Biscay, and northwestern Europe to Norway and west to Iceland (Reeves *et al.* 2007). In the Western Atlantic, they still occupy most of their historic range.

Surveys conducted since the late 1970s have identified six areas (5 are identified or designated Critical Habitat) that are seasonally important to Right Whales along the east coast of North America (Fig. 3). Four of these areas are in the United States (southeastern United States, Cape Cod Bay, the Great South Channel and Georges Bank/Gulf of Main; Kraus and Kenney 1991; NMFS 1994) and two are in Canada (Grand Manan Basin in the Bay of Fundy and Roseway Basin on the western Scotian Shelf; (Brown *et al.* 2009)). North Atlantic Right Whales also occupy Jeffreys Ledge, off Massachusetts (Weinrich *et al.* 2000), and have been reported occasionally in large numbers in other areas such as Rhode Island Sound during spring in some years (e.g.,1998, 2010, 2011; Kenney 2010; Unpublished NMFS sightings data 2010).

North Atlantic Right Whales usually give birth in relatively warm waters at the southern end of their range from November to April. Most births occur in the coastal waters of Georgia and Florida (Kraus and Brown 1992), but recent observations suggest that a few take place elsewhere and possibly somewhat later in the year (Brown *et al.* 2001; Patrician *et al.* 2009).

Cow-calf pairs spend about 1-2 months on the calving grounds (Fortune *et al.* 2013) before travelling north along the coast to feed in the Great South Channel and Cape Cod Bay during spring. Most will ultimately summer in the lower Bay of Fundy from late July to mid-October, although some Right Whales have been seen there as early as May and as late as December (Stone *et al.* 1988; Murison and Gaskin 1989; Woodley and Gaskin 1996; Baumgartner and Mate 2003; Mellinger *et al.* 2007). A second summer and fall nursery area may exist between Cape Farewell (Greenland) and Iceland (Reeves and Mitchell 1986; Knowlton *et al.* 1994).

Individuals from all demographic groups are known to occur on the calving grounds, but pregnant and parturient females appear to spend more time there than other whales (Fortune *et al.* 2013). Most non-pregnant Right Whales winter elsewhere—but the locations used by non-calving ("resting") females are unknown (Kraus and Rolland 2007). Jordan Basin, located in the Gulf of Maine between the Northern Coastal Shelf and the Eastern Coastal Shelf, appears to be an important breeding ground (Cole *et al.* 2013).

Canadian Range

In Canadian waters, concentrations of Right Whales consistently occur in the lower Bay of Fundy and on the Scotian Shelf (Mitchell *et al.* 1986; Winn *et al.* 1986) (Fig. 3). Right Whales have also been sighted in the deep basins in the lower St. Lawrence River near the confluence of the Saguenay River (R. Michaud, pers. comm. in 1998, de la Chenelière pers. comm. 2010), near the Mingan Islands off the lower North Shore of Quebec (R. Sears pers. comm. in 1994, 1995 and 1998, cited here based on previous COSEWIC status report), and near Percé on the Gaspé Peninsula (N. Cadet, pers. comm, J.F. Boulin pers. comm. cited in Brown *et al.* 2009).

Right Whales are regularly observed to nurse, feed, and socialize during the summer and autumn in the lower Bay of Fundy between New Brunswick and Nova Scotia (Kraus *et al.* 1982; Goodyear 1996). They are also observed feeding and socializing on the western Scotian Shelf about 50 km south of Nova Scotia (Stone *et al.* 1988; Kraus and Brown 1992; Brown *et al.* 1995) (Stone *et al.*1988; Kraus and Brown 1992; Brown *et al.* 1995). Right Whale calls on the Scotian Shelf peak between August and October, but occur to some extent from July until the end of December, suggesting that at least few individuals are still present in early winter (Mellinger *et al.* 2007).

Right Whales have not been reported for more than four centuries (1600s) in the Strait of Belle Isle (between Labrador and Newfoundland), where Right Whales may have co-occurred to some extent with Bowhead Whales (*Balaena mysticetus*) (Aguilar 1986; Cumbaa 1986). Although it was long thought that Right Whales were hunted there during summer, and Bowhead Whales from late autumn through spring (Cumbaa 1986; Reeves and Mitchell 1986), analyses of DNA extracted from bone material found in Basque whaling sites (e.g., at Red Bay, Labrador) indicate that mostly Bowheads were taken and that the Strait of Belle Isle was not important habitat for Right Whales (Rastogi *et al.* 2004). There is also only limited evidence that Right Whales were hunted historically in the Bay of Fundy (Reeves and Barto 1985) and on the Scotian Shelf (see Right Whale hunts in the Gulf of St. Lawrence referenced in Mitchell *et al.* 1986). Their distribution may have changed over time, or the current habitat-use pattern could represent that of a relict population that uses only the southern periphery of the species' formerly more extensive range (Kenney *et al.* 2001).

Based on historical whaling records and recent sightings data, the extent of occurrence in Canada is estimated to be ~1.8 million km^2. There are several ways to estimate the index of area of occupancy (IAO): (a) using only the identified Critical Habitat within Canada (Grand Manan Basin in the lower Bay of Fundy and Roseway Basin on the Scotian Shelf, both feeding grounds), ~4,500 km^2; (b) using all main feeding grounds legally identified as Critical Habitat in Canadian waters (Grand Manan Basin, Roseway Basin) and designated as Critical Habitat in the United States (Cape Cod Bay, Great South Channel), ~ 15,820 km^2; and (c) using only the legally designated Critical Habitat off the southeastern United States (calving grounds), 7092 km^2. The last of these best fits the definition of the smallest area essential at any stage to the survival of the wildlife species, which does not need to occur within Canada.

The proportion of the North Atlantic Right Whale population using Canadian waters in a given year is uncertain and probably varies by year. In general, it is believed that ~60% of lactating females bring their calves to the Bay of Fundy (Frasier *et al.* 2007b), while the remainder spend the summer/fall feeding season elsewhere (Malik *et al.* 1999). It is possible that all individuals in the North Atlantic population move into or through Canadian waters at some point in most years.

The distribution and abundance of North Atlantic Right Whales have been assessed in U.S. waters since 1978 and in Canadian waters since 1979. Systematic vessel and aerial surveys have been conducted during the summer and fall when large concentrations occur in the lower Bay of Fundy and Roseway Basin (Tables 1). Such surveys began with the Cetacean and Turtle Assessment Program in U.S. and Canadian waters (CETAP 1982). Surveys of Right Whale distribution and demography in Canadian waters have been conducted principally by the New England Aquarium, beginning in 1980 in the Bay of Fundy (annually) and 1981 in Roseway Basin (often but not annually) (Hamilton *et al.* 2007). Other aerial surveys in Canadian waters include those conducted by the University of Rhode Island in 1987 and 1989 (as part of a radio tagging project) and 1992 (searching for individuals absent from the Great South Channel). In 1998 East Coast Ecosystems conducted surveys of the Scotian Shelf and approaches to the Bay of Fundy. The U.S. National Oceanic and Atmospheric Administration (NOAA) also conducted aerial and shipboard surveys in the Bay of Fundy and Scotian Shelf in some years. Starting in 2006, surveys were conducted collaboratively south of the Gaspé Peninsula by the Canadian Whale Institute, the Centre d'Études et de Protection de la Baleine Noire du Saint-Laurent and the New England Aquarium.

In addition to vessel and aerial surveys, autonomous hydrophones have been deployed to detect the presence of Right Whales in historically important areas such as Roseway Basin and the Scotian Shelf (Brown *et al.* 1995; Mellinger *et al.* 2007). Sonobuoy studies were also conducted in the Bay of Fundy (Laurinolli *et al.* 2003), and individual movements and vocalizations have been monitored in Canadian waters using archival suction-cup tags (e.g., Nowacek *et al.* 2004), time-depth recorders (e.g., Baumgartner and Mate 2003) and satellite tags (e.g., Mate *et al.* 1997; Baumgartner and Mate 2005).

HABITAT

Habitat Requirements

North Atlantic Right Whales occupy areas encompassing a wide range of depths and distances from shore—shallow coastal waters, deep coastal waters and offshore waters (Fig. 4). Pregnant and lactating females frequent shallow coastal waters in southern parts of the range from about November to April. The relative warmth of coastal waters off the southeastern United States (~20°C) may allow calves to allocate less energy to thermoregulation and more to growth (Keller *et al.* 2006). Migration to these waters may also reduce the risk of predation by White Sharks (*Carcharodon carcharias*) and Killer Whales (*Orcinus orca*) (Kenney 2002; Reeves and Kenney 2003; Ford and Reeves 2008; Hamilton and Cooper 2010; Cassoff *et al.* 2011).

Four main feeding areas are recognized: Cape Cod Bay (Massachusetts), Great South Channel (Massachusetts), Grand Manan Basin and Roseway Basin. Between January and mid-May, Right Whales aggregate to feed in the shallow waters of Cape Cod Bay where wind, currents and thermal stratification concentrate zooplankton prey in dense surface patches (DeLorenzo Costa *et al.* 2006). They also forage in the Great South Channel (Massachusetts) between April and July (Kenney *et al.* 1986), and in the Bay of Fundy and Roseway Basin from late July through mid-October (Baumgartner *et al.* 2003). These are deep basins flanked by shallow water and copepods are concentrated in these areas by convergence, upwelling and other currents (Wishner *et al.* 1988; Kenney *et al.* 1995; Kenney and Wishner 1995).

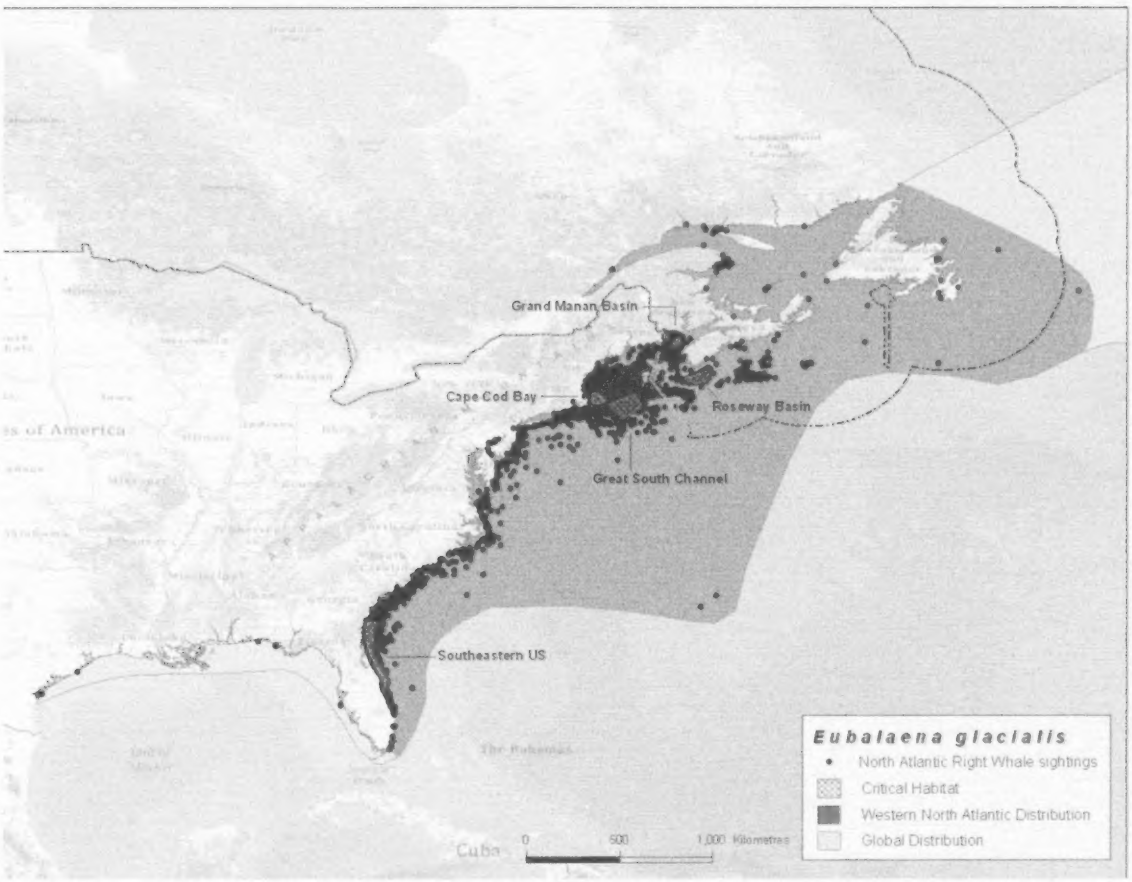

Figure 4. Distribution of North Atlantic Right Whales inferred from sighting data in U.S. and Canadian waters from 1849 to 2010. Sighting data are from the North Atlantic Right Whale Consortium database (Right Whale Consortium 2011) and were not effort-corrected or peer-reviewed. Each dot represents a sighting event rather than an individual whale.

Successful foraging is thought to require a threshold density of prey (Kenney *et al.* 1986; Mayo *et al.* 2001). In the Grand Manan Basin, Right Whales are known to dive to depths of 90-150 m (near the sea floor) in areas where copepod biomass is high, but they have not been observed feeding where prey concentrations are < 820 organisms/m^3 (170 mg/m^3) (Murison and Gaskin 1989). Particle densities in the presence of foraging Right Whales have ranged between ~2,000 and 21,000 organisms/m^3 (mean ~7,500 organisms/m^3) in the Bay of Fundy (Baumgartner and Mate 2003) and >1,000 zooplankton organisms/m^3 in Cape Cod Bay (Mayo and Marx 1990).

Habitat Trends

Human activity has degraded Right Whale habitat in a number of ways. Major increases in ship traffic, for example, have heightened the risk of vessel strikes (Hackett 2003; Ward-Geiger *et al.* 2005) and contributed to greater background noise (Parks *et al.* 2011). Acoustic masking decreases the ability of Right Whales to communicate (Clark *et al.* 2009). Endocrine-disrupting chemicals found in Right Whale tissue may cause reproductive dysfunction (Woodley *et al.* 1991; Weisbrod *et al.* 2000; Kraus *et al.* 2007).

There is evidence that environmental changes associated with the North Atlantic Oscillation (NAO) affect the quality of Right Whale habitat. The NAO affects wind speed and direction, air temperature, rainfall and the intensity, frequency and track of storms (Greene and Pershing 2000; Visbeck *et al.* 2001), which in turn control the advection of *Calanus finmarchicus*, the whales' major copepod prey, into foraging habitats such as Grand Manan Basin (Greene and Pershing 2000; Greene *et al.* 2003; Greene *et al.* 2004). *C. finmarchicus* availability differs between positive and negative NAO years, with higher abundance and predictability during positive NAO years (Conversi *et al.* 2001; Turner *et al.* 2006). Thus, habitat conditions (i.e., prey densities) likely will fluctuate more frequently in coming years because the periodicity of the NAO (variation between positive and negative phases) is predicted to increase (Greene and Pershing 2004).

BIOLOGY

Life Cycle and Reproduction

Females are thought to give birth in the coastal waters of the southeastern United States, mainly between Brunswick, Georgia, and Jacksonville, Florida, between November and April (Kraus *et al.* 1986b; Firestone *et al.* 2008). Parturient and lactating females reside in the calving grounds for 1-2 months (Fortune *et al.* 2013), and depart for the northern feeding areas with their calves from early to mid-March (Winn *et al.* 1986; Kraus and Kenney 1991; Kraus *et al.* 1993; Firestone *et al.* 2008). Calves are suckled for about a year, but this can extend into a second year (Hamilton and Cooper 2010). Females become pregnant again one or more years after their calves have been weaned (Knowlton *et al.* 1994). Gestation is ~12 months (Best 1994), suggesting that breeding occurs during winter when adult males and non-calving females are scattered along the east coast of the United States (between the calving grounds and at least as far north as the Central Gulf of Maine at least into February; Cole *et al.* 2013).

The age of first observed birth, determined from photo-identification studies, has been used as a proxy for sexual maturity in females, and ranges from 5-21 years, with a mean of 10 years (Kraus *et al.* 2007). However, the assumed age at sexual maturity is likely over-estimated because of neonatal and perinatal mortality and limited survey coverage (Browning *et al.* 2010). The reproductive lifespan of Right Whales is at least 31 years based on observations of two females (Kraus *et al.* 2007). The mean age of all mothers with calves (i.e., the mean generation time) from 2002 to 2009 was 16.1 years (±1.54 SD, range 13.1-18.4 years; unpublished data calculated from Right Whale Consortium 2011). However, this value is expected to increase over time as population growth slows and ages of all older females become known. Population modelling suggests that a mean age of mothers of 35.7 years is appropriate for a stationary pristine population assuming a reproductive life span from 10 to 69 years and a uniform death or reproductive senescence of 1% (Taylor *et al.* 2007). This estimate of generation time is likely high, but better estimates of reproductive life expectancy for North Atlantic Right Whales are not available. Thus generation length for this population is between 16 and 36 y.

The birth rate (based on 106 adult females and 19 calves born in 2010) was 0.18 calves per mature female (Hamilton and Knowlton 2011), and the average number of calves born from 1993-2010 was 17.5 (range 1-39 calves born per year).

Except by post-mortem examination and fecal hormone analysis (Rolland *et al.* 2007), there is no means to determine the age of sexual maturity in males. Males of all ages have been seen in courtship groups (Kraus and Hatch 2001), but genetic analysis indicates that the age of first paternity is ~15 years, suggesting that competition prevents younger males from contributing to reproduction (Frasier *et al.* 2007a).

The reproductive strategy of Right Whales is thought to be partially based on sperm competition. Males have penises up to ~2.3 m long and testes with a combined weight of up to ~972 kg (Brownell and Ralls 1986; Frasier *et al.* 2007a)—the largest testes and highest ratio of testes to body weight of any mammal, and one of the highest ratios of penis length to body length (Brownell and Ralls 1986; Atkinson 2002; Frasier *et al.* 2007a). Assuming large testes and exceptional penis length indicate a mating strategy involving rivalry (Ginsberg and Huck 1989; Gomendio *et al.* 1998; Frasier *et al.* 2007a), Right Whales may have the most intense sperm competition of all whale species and possibly of all mammals (Frasier *et al.* 2007a). Observations of courtship groups support this idea (although the majority of courtship groups are observed outside of the presumed breeding period; Parks *et al.* 2007a).

The annual calving interval of 3-5 years (Kraus *et al.* 2007) results in roughly one ovulating female to every four adult males, leading to significant competition among males for females. Courtship groups may include 40 animals or more, as multiple males try to mate with the focal female (Kraus and Hatch 2001). Females elicit male attention by vocalizing (Parks and Tyack 2005). Males appear to compete for positions that provide the best opportunity for mating when the female breathes (Kraus and Hatch 2001). The female may copulate ~60 times during a courtship bout with several different males and on some occasions, double intromission occurs (Mate *et al.* 2005; Parks and Tyack 2005; Frasier *et al.* 2007a). These observations further suggest a mating system dependent on sperm competition (Frasier *et al.* 2007a).

An adult female may produce one offspring at a time, with a highly variable interval between births (average 3-5 years and range 2-13; Kraus *et al.* 2007). The sex ratio at birth is probably 50:50. However, in 2010, 49% of non-calves were males, 35% were females, and 17% were of unknown sex (Hamilton and Knowlton 2011). The sex ratio of the known individuals was skewed towards males (58:42), and would be nearly 50:50 only if all of the individuals of unknown sex were females. Since the 1990s, juveniles have consistently made up 26-31% of the population of known individuals older than one year. Adults comprise 65-69% of the population, and the remaining 4-6% are of unknown ages (Hamilton *et al.* 1998; Hamilton *et al.* 2010; Hamilton and Knowlton 2011).

Reproductive output (measured by numbers of calves born) is highly variable. Since 1990, the number of calves observed each year has varied from 1-39, which is more variable than would be predicted by chance alone (Kraus *et al.* 2007; Waring *et al.* 2011) (Fig. 5). This was particularly true between two time periods (1993-1995 and 1998-2000) when the number of births was particularly low (Kraus *et al.* 2007). Years of high reproductive output followed these years of low output (Kraus *et al.* 2007). It has been suggested that ocean fluctuations that influence the abundance of primary prey (*Calanus finmarchicus*) ultimately affect the reproductive success of Right Whales (Greene and Pershing 2004; Kraus *et al.* 2007). However, current models are unable to predict future reproductive output accurately and this makes it impossible to forecast trends with any confidence.

The coastal waters of the southeastern United States are widely acknowledged to be where most calves are born (Kraus and Brown 1992). However, recent observations of mothers accompanied by very young calves with characteristics of neonates (e.g., small head size, a pronounced dip in the rostrum, and poor callosity formation) suggest that a second calving ground may exist farther north, possibly off Massachusetts (Patrician *et al.* 2009). Historical observations of at least two small calves in Cape Cod Bay are consistent with the presence of a local calving area (Watkins and Schevill 1982; Schevill *et al.* 1986). The presence of such an area could help explain why 25% of reproductively active (i.e., lactating) females were unaccounted for on the southeastern U.S. calving ground from 1980 to 1992 (Brown *et al.* 2001).

Natural mortality rates have not been calculated. Mean longevity is unknown, although some recognizable adults have been seen for more than three decades, and the oldest recorded North Atlantic Right Whale was ~70 years old when last seen (Kraus and Rolland 2007).

Physiology and Adaptability

Rapid growth and blubber storage are two physiological adaptations that may improve the survival probability of offspring and assist in reproductive success. According to growth models, North Atlantic Right Whale calves attain ~75% of their asymptotic length during their first year of life prior to weaning (Fortune *et al.* 2012). This rapid postnatal growth may improve offspring survival by reducing the risk of predation and optimize the size of the head and mouth to enhance foraging success immediately after weaning. Accelerated growth may also reduce thermoregulatory costs by decreasing the calf's surface-area-to-volume ratio.

Blubber may also improve reproductive success of adult females that fast while on the calving grounds. Measurements taken using ultrasound imaging indicate that lactating females catabolize blubber and replenish reserves after their calves have been weaned (Miller *et al.* 2011). Blubber thickness is greatest a few months prior to the onset of pregnancy, and lactating females are skinnier (in terms of blubber thickness) than non-lactating, non-pregnant females (Miller *et al.* 2011).

Blubber thickness is known to correlate with prey availability and reproductive success (Miller *et al.* 2011). Annual variability in calving intervals corresponded with changes in blubber thickness in the mid-1990s and fluctuations in fat stores coincided with large-scale environmental changes thought to control prey quality and quantity. Observed decreases in blubber thickness followed a drastic decline in the NAO index in 1996. Conversely, blubber thickness increased in years of moderate resource availability.

Similar trends in blubber thickness and prey availability are found in immature animals. For example, blubber of yearlings was significantly thicker in 2002 than in 1998 (Miller *et al.* 2011). Hypothesized reasons for the variability of juvenile blubber thickness include improved nutrition while being nursed, increased suckling time as yearlings were observed in close proximity to their mothers well beyond a year after birth, and differences in the abundance of *Calanus finmarchicus* between 1998 and 2002 (Hamilton and Cooper 2010; Miller *et al.* 2011).

Dispersal and Migration

The northward migration of Right Whales begins in the late winter and early spring. According to statistical migration models, cow-calf pairs arrive at the tip of Long Island (New York) 21-24 days after leaving the coastal waters of Florida (assuming movement of 2.8 to 3.1 km/h; Firestone *et al.* 2008). Right Whales of all ages aggregate to feed and socialize in Cape Cod Bay in the mid-winter and spring and the Great South Channel east of Cape Cod (Winn *et al.* 1986; Hamilton and Mayo 1990; Kenney *et al.* 1995) in the spring. In June and July whales move to feeding grounds in the lower Bay of Fundy and on the western Scotian Shelf where they feed intensively from August to September (Mitchell *et al.* 1986; Winn *et al.* 1986; Baumgartner and Mate 2003; Mellinger *et al.* 2007). Residency times in the Bay of Fundy during the summer and fall are variable and may be influenced by ocean conditions and prey quality (Baumgartner and Mate 2005).

Individually identifiable whales have been documented in the Gulf of St. Lawrence as well as the Labrador Basin during the summer (Knowlton *et al.* 1992; Hamilton and Martin 1999). They occur at least occasionally in summer on the eastern Scotian Shelf (Mitchell *et al.* 1986), in the St. Lawrence Estuary near the confluence of the Saguenay River (1998), off the Mingan Islands along the lower North Shore of Quebec (1994, 1995, and 1998), and near the mouth of Chaleur Bay (Baie-des-Chaleurs) south of the Gaspé Peninsula (1995-1998 and 2000-2006). In 2001, a Right Whale was found dead in the Gulf of St. Lawrence near the Magdalen Islands (unpubl. data, New England Aquarium; Brown *et al.* 2009), and another (entangled whale) was tracked by satellite travelling along the eastern Scotian Shelf and into the Gulf of St. Lawrence to the Magdalen Islands and then back to the Scotian Shelf and finally south into the Gulf of Maine (unpubl. data, Provincetown Center for Coastal Studies; Brown *et al.* 2009).

A southward migration begins in October with some animals passing through the Gulf of Maine and off Cape Cod (Winn *et al.* 1986). Right Whale aggregations are sometimes observed in the autumn on Jeffreys Ledge (Weinrich *et al.* 2000), Cashes Ledge, and Platts Bank (P. Clapham, pers. comm. 2003) (Waring *et al.* 2011).

A few trans-Atlantic movements have been documented. In the fall of 1999, an adult male travelled 5,700 km from Cape Cod Bay to northern Norway in ~117 days (49 km/day or 2 km/h) (Jacobsen *et al.* 2004). Right Whales had not been observed in Norwegian waters since 1926 (Jonsgard 1977; Smith *et al.* 2006). Another individual known from the western North Atlantic catalogue was observed in the Azores 9 January 2009 (Silva *et al.* 2012).

Nutrition and Interspecific Interactions

Right Whales eat primarily calanoid copepods and occasionally euphausiids and barnacle larvae (Mayo and Marx 1990). During winter they feed in Cape Cod Bay on numerous copepod species (e.g., *Calanus finmarchicus, Centropages typicus, Centropages hamatus* and *Pseudocalanus* spp.). However, during the spring in Cape Cod Bay and the summer and early fall, in the Bay of Fundy, they feed almost exclusively on the oil-rich developmental stages of *C. finmarchicus* (Murison and Gaskin 1989; Mayo and Marx 1990; Mayo *et al.* 2001; Baumgartner *et al.* 2003; Baumgartner and Mate 2003).

Sei Whales (*Balaenoptera borealis*) (Baumgartner *et al.* 2011), Basking Sharks (*Cetorhinus maximus*) (e.g., Sims and Quayle 1998), Herring (*Clupea harengus*) (e.g., Checkley Jr 1982) and Sand Lance (*Ammodytes* spp.) (e.g., Monteleone and Peterson 1986) have diets similar to that of Right Whales and are considered potential competitors. Species such as *C. finmarchicus* may take refuge from planktivorous fish such as Herring and Sand Lance, and from planktivorous whales such as Sei Whales in the poorly lit zones. The ability of Right Whales to detect and exploit copepod aggregations at considerable depths suggest that Sand Lance, Herring, Sei Whales and Right Whales would predominately compete for copepods in surface waters (Baumgartner *et al.* 2011).

POPULATION SIZE AND TRENDS

Sampling Effort and Methods

The number of individuals known (or presumed) to be alive is considered the best estimate of population size although it must be considered a minimum (e.g, Waring *et al.* 2011). Researchers have generally concluded that for this population, there is no means of generating a credible maximum number with an associated estimate of the range of uncertainty (Hamilton et al. 2007). The number alive includes uniquely marked whales that have been photographed within the past six years matched (using callosity patterns) with the identification database maintained by the New England Aquarium (Hamilton *et al.* 2007). Animals not sighted for more than 6 years are presumed dead. It is acknowledged that a small number of the whales "presumed dead" may still be alive and also that a few "irregular" whales probably have not been photographed (Hamilton et al. 2007).

Annual sampling effort in identified or designated Right Whale Critical Habitat has been high, although not evenly distributed. Some areas such as Roseway Basin are not surveyed every year (Table 1), and the number of surveys conducted each year differs between areas. Most notably, sampling has been much more intensive on the calving grounds (with multiple surveys per week) than the feeding grounds (Cape Cod Bay has been surveyed about once per week in recent years). Much of the effort, especially on the calving grounds, has consisted of aerial surveillance in order to alert vessel operators of near-real-time locations of right whales and thereby help them avoid ship strikes.

Table 1. Years of systematic surveys (vessel and aerial) for North Atlantic Right Whales in Canadian waters (from Brown *et al.* 2007).

Survey Area	Institution	Years
Cape Hatteras (U.S.) to Scotian Shelf	Cetacean and Turtle Assessment Program, University of Rhode Island	1979 to 1982
Bay of Fundy	New England Aquarium	1980 to 2011
Roseway Basin	New England Aquarium	1981, 1983 to 1985, 1986 to 1991, 2004 to 2005, 2009 to 2010

Visual surveys following systematic designs have been conducted in the Bay of Fundy since 1980 and in Roseway Basin since 1981 (Brown *et al.* 2007), with some gaps from years without surveys (Table 1). Survey effort has been ~3 times greater in Grand Manan Basin in the Bay of Fundy than in Roseway Basin (90,812 km were systematically surveyed in the Bay of Fundy and 28,563 km were surveyed in Roseway Basin between October 1978 and 2010). The following criteria were applied in these estimates of survey effort: 1) the data were collected systematically (aerial or shipboard survey), 2) the complete data set was submitted to the North Atlantic Right Whale Consortium, 3) at least one observer was formally on watch, 4) visibility was at least 3.7 km and sea state was Beaufort 4 or better, and for aerial surveys 5) the altitude was below 365.76 m (Kenney pers. comm. 2011. Email correspondence to S. Fortune. September 2011. Associate Marine Research Scientist, Professor-in-Residence, University of Rhode Island, Rhode Island, USA).

Abundance

As indicated in the COSEWIC O&P manual (August 2013, Appendix C, p 149), the number of mature individuals is the number of individuals known, estimated or inferred to be capable of reproduction. This means that when it possible to adjust the total number of living adults to account for non-reproducing individuals, such adjustments should be made. In the case of North Atlantic Right Whales, two classes of adults need to be considered. First, individuals that will never produce new recruits (e.g., those that are sterile or reproductively senescent) should not be counted. Second, because of the biased sex ratio of adults (more males than females), "it is appropriate to use lower estimates for the number of mature individuals that take this into account" (O&P manual, p. 149).

The total number of North Atlantic Right Whales believed to be alive in 2010 was 468. This included 19 calves of the year and 449 non-calves (ages 1+ years) (Pettis 2010; Hamilton and Knowlton 2011) (Fig. 5). A small number of juveniles were not individually recognizable and thus not included in the catalogue or the estimate of total population size (likely <10 individuals based on data from previous years). In 2010, the population of 468 Right Whales consisted of 4% calves (n=19), 27% juveniles (1-8 years) (n=124), 65% adults (≥9 years) (n=305), and 4% of unknown ages (n=20) (Hamilton and Knowlton 2011). Those of unknown age are likely to be older animals that were not observed in the year of their birth, but there is insufficient information to determine whether they are adults or juveniles. Thus, the total adult population in 2010 was likely between 305 and 325 individuals.

Based on the shape of the discovery curve (i.e., a steady reduction in the number of non-calves added annually to the photo-identification database over time; Fig. 6), it appears that most of the population has been photographically identified. Note that neither Figure 6 nor 7 should be interpreted as portraying the actual or assumed number of animals alive in a given year from 1980 to 2009. Rather, the plateauing of the lower curve in Figure 6 suggests that researchers have discovered all adults in the population, while the increasing upper curve in Figure 6 indicates that the new individuals being added to the catalogue are almost entirely from new production—i.e., calves. These discovery curves are not estimates of abundance and do not account for animals that died sometime after "discovery" and were hence removed from the catalogue. Of the 449 non-calves presumed to be alive in the 2010, 49% were males, 35% were females, and 17% were of unknown sex (Hamilton and Knowlton 2011).

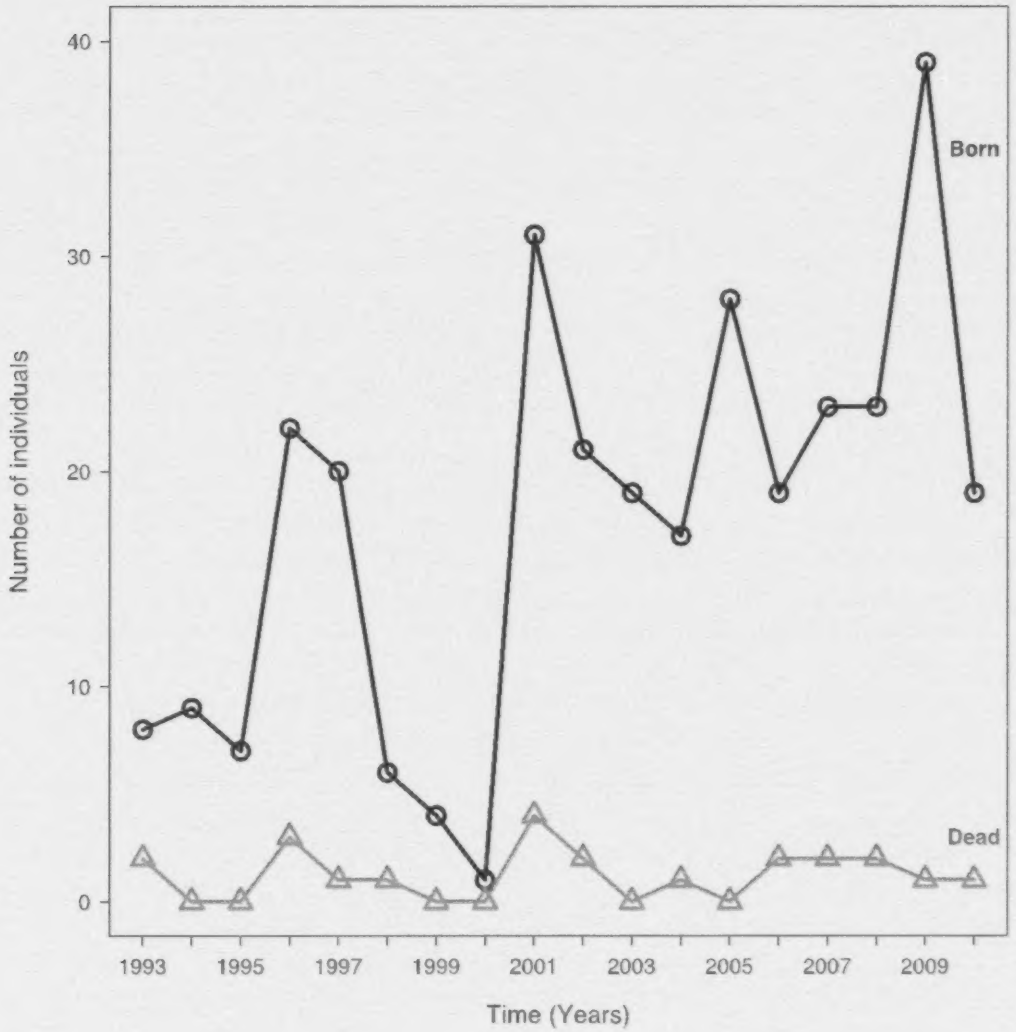

Figure 5. Total numbers of North Atlantic Right Whale calves (young of the year) observed alive and dead each year between 1993 and 2010 (Pettis 2010; Waring *et al.* 2011). At least some of the dead calves would have also been observed alive and therefore would be "counted" twice in the figure.

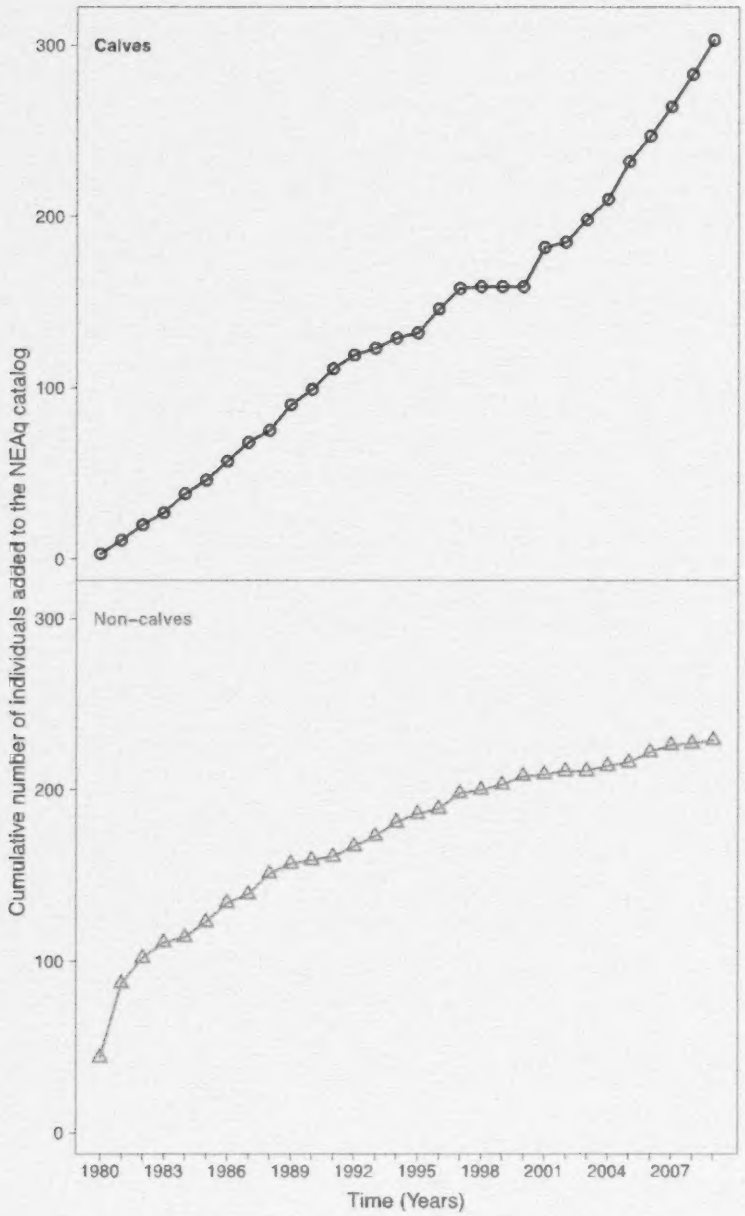

Figure 6. Cumulative number of calf (0-1 years) and non-calf (>1 years) North Atlantic Right Whales that were added to the New England Aquarium catalogue from 1980 to 2009 (Hamilton *et al.* 2007). Note that the number of calves added to the catalogue does not equal the number of calves born each year because identification of newborn whales is difficult (due to incomplete callosity formation) and many calves are not identified until later (in the Bay of Fundy at ~6 months) once their callosity patterns are better developed. Note that therefore it is not unusual for a calf to be born in one calendar year but first photo-identified in the next calendar year while it is still classified as a calf. Note also that the non-calves include only animals that were not first seen and photo-identified as calves. The plateauing of the non-calf curve suggests that all (or nearly all) non-calves have now been identified and that all new North Atlantic Right Whales are being first detected as calves.

The effective number of mature Right Whales that were alive in 2010 is less than the sum of all possible adults (i.e., 305 plus the 20 catalogued animals of unknown age = 325 individuals) because the sex ratio was significantly skewed towards males (58%:42%). Some of the adult males can thus be considered surplus to the breeding needs of the population.

Applying the sex ratio of known-sex animals to the maximum number of 325 adults estimated to be alive in 2010 suggests there were 188 mature males and 136 mature females, which would indicate an effective population of 272 mature individuals by adjusting the number of males to be equal to, and not larger than, the number of females (= 2 x 136 females). However, the number of mature animals would be lower if some of the mature females were nulliparous, i.e., incapable of reproducing. Approximately 10% of the adult females (12 of 125) were thought to be nulliparous from 1989 to 2003 (Browning *et al.* 2010). Having 10% of the females never giving birth would reduce the effective population from 272 to 245 mature Right Whales (= 2 x 122.5 females). However, the assumption that 10% of females >10 years old are nulliparous may be too high given that calving rates in the population were relatively low from 1989 to 2000 (Fig. 5) and that 11 of the 12 identified nulliparous females (1989-2003) were sighted on the calving grounds, indicating that they may have conceived but either aborted or lost their calves while travelling there (Browning *et al.* 2010). It is therefore reasonable to consider the effective population size to have been between 245 and 272 mature individuals in 2010.

Fluctuations and Trends

The age structure of the North Atlantic Right Whale population has been relatively stable over time, and the number of adults newly identified has fluctuated little from year to year (Fig. 6). Of non-calves (ages 1+ y) in the photo-identification catalogue, juveniles have consistently made up 26-31% of the population since the 1990s; adults have represented 65-69% of the population, with the remaining 4-6% being of unknown ages (Hamilton *et al.* 1998; Hamilton and Cooper 2010; Hamilton *et al.* 2010; Hamilton and Knowlton 2011).

The number of calves born is highly variable. Since 1990, the number of calves documented annually has ranged from 1 to 39 (Kraus *et al.* 2007; Waring *et al.* 2011) (Fig. 5). The number was particularly low from 1993 to 1995 and from 1998 to 2000. These periods of low calf production were followed by years of high reproductive output (Kraus *et al.* 2007). Reproductive success may be regulated by food availability (Greene and Pershing 2004; Kenney 2007; Kraus *et al.* 2007; Hlista *et al.* 2009; Browning *et al.* 2010). Despite inter-annual variability in the birth rate, there has been an overall increase in the numbers of calves added annually to the photo-identification catalogue (Fig. 6).

The population (ages 1+ y) appears to have experienced phases of increase and decrease since the 1980s. It was estimated to have increased at ~2.5% (SE 0.3%) per year from 1986 to 1992 (Knowlton *et al.* 1994). However, later in the 1990s, it apparently declined somewhat, or at least failed to increase at the previous rate, because of relatively low calf production and high adult mortality (Caswell *et al.* 1999; Fujiwara and Caswell 2001; Kraus *et al.* 2007).

In 2003, there were 322 known individuals (non-calves) (Right Whale Consortium 2011), which increased to 396 in 2007 (Waring *et al.* 2011), 417 in 2009 (Hamilton *et al.* 2010) and 449 in 2010 (Hamilton and Knowlton 2011) (Fig. 7). The number of non-calves has thus increased by ~28% since 2003 (Fig. 7). However, the number of mature individuals may have increased by only ~22-27% (assuming 222-238 mature individuals in 2003). The overall population size (including all individuals) thus doubled between 1990 and 2010.

The mean crude rate of increase (based on annual changes in the minimum number of animals alive) was 2.4% between 1990 and 2007 (Waring *et al.* 2011). More recently, Waring *et al* (2013) found a population growth rate of 2.6% from 1990 to 2009. These increases are lower than annual rates of increase for two populations of Southern Right Whales: 6.8% in South Africa (1971-1998, n=3,104 whales in 1997; Best *et al.* 2001; IWC 2001a) and 6.9% in Argentina (1971-1990; Cooke and Rowntree 2001).

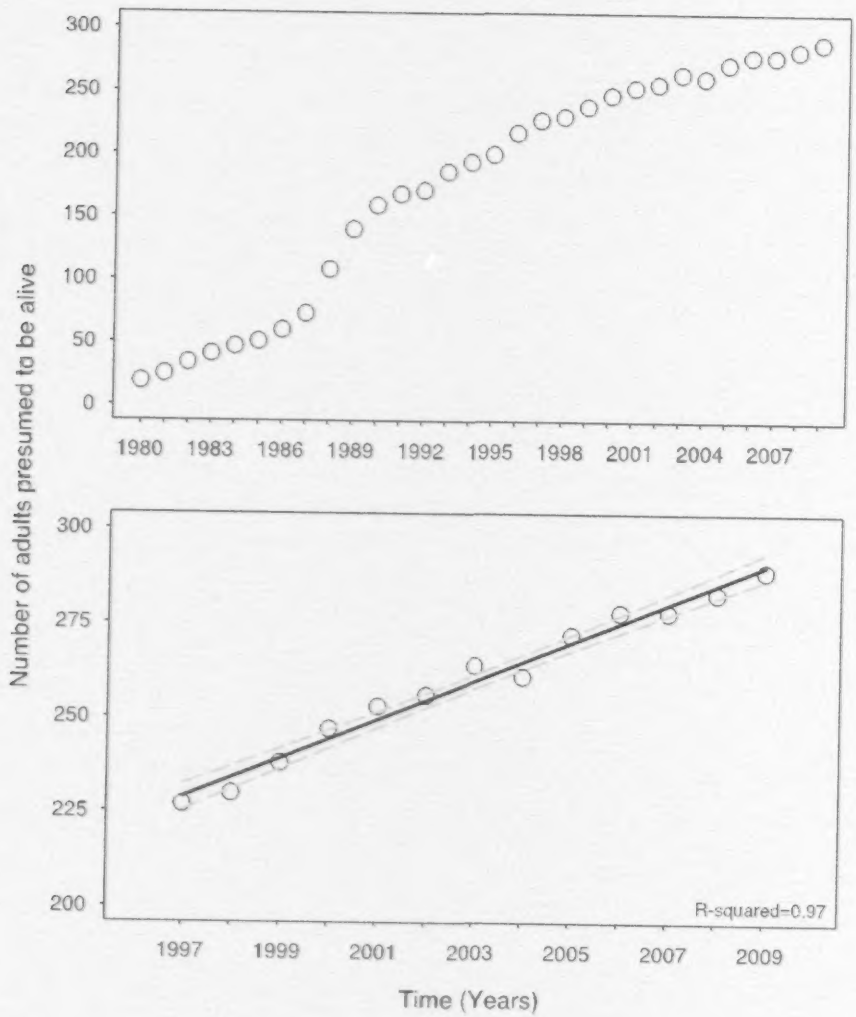

Figure 7. Upper panel: Annual number of adult North Atlantic Right Whales (≥ 9 y old) presumed to be alive between 1980 and 2009 (based on identified individuals in the photo-identification catalogue, Right Whale Consortium 2011). The true total number is likely larger than shown because the photo-identification catalogue may not include adults that do not regularly visit or occupy surveyed habitat. Also, individuals that have not been observed and identified for 6 years or longer are excluded even though some of them may still be alive. Lower panel: Linear relationship between the number of adults presumed to be alive between 1997 and 2009 (i.e., a period of time when ~75-100% of the total number of adults presumed to be alive).

The size of the pre-exploited population of North Atlantic Right Whales is unknown. Reconstructing population size from historical whaling data is challenging (Reeves *et al.* 2007). Between 1634 and 1950 a minimum of 5,500 (maximum ~11,000) Right Whales were killed in the western North Atlantic, and it is inferred that the population likely numbered at least a few thousand before exploitation began in the early 1600s (Reeves *et al.* 2007).

Analyses of mitochondrial DNA (mtDNA) from over 200 animals sampled in the western North Atlantic suggest that there are presently only six matrilines (or mtDNA haplotypes) and that the population went through a "bottleneck" (Malik *et al.* 1999; McLeod *et al.* 2010). This bottleneck may have occurred before Basque whaling in the 1500s, given the small numbers of Right Whale bones recovered from archaeological sites at Basque whaling stations (Rastogi *et al.* 2004; McLeod *et al.* 2010). Nine such stations were located along Quebec and Labrador in the Strait of Belle Isle during the 16th century (Barkham 1978; Braham and Rice 1984). Genetic analysis conducted on 21 humeri excavated at Red Bay, Labrador from a Basque whaling galleon (sunk in 1565) contained one humerus from a Right Whale and 20 from Bowhead Whales (Rastogi *et al.* 2004). This has been interpreted to mean that the current smallness of the population in the western North Atlantic is not a recent phenomenon (Rastogi *et al.* 2004; Frasier *et al.* 2007a; Frasier *et al.* 2007b; McLeod *et al.* 2010).

The genetic bottleneck may have occurred sometime before the 1500s, following a shift in environmental conditions that changed the quality and quantity of prey (Frasier *et al.* 2007b). It has been suggested that the last major glaciation event (lasting from ~300,000 until 10,000 years ago) was responsible for the change in biotic and abiotic conditions (Frasier *et al.* 2007b). Although such a hypothesis is untestable, recent observations of Right Whales in poor condition and evidence of low genetic diversity suggest that nutritional and genetic factors may be affecting the recovery rate of the population (Frasier *et al.* 2007b; Brown *et al.* 2009).

Rescue Effect

Right Whales that spend the spring, summer and fall feeding in Canadian waters belong to the same population as calves in the southeastern United States and Right Whales are essentially extirpated from the eastern North Atlantic. Therefore, no chance of rescue effect is possible.

THREATS AND LIMITING FACTORS

Vessel Strikes and Fishing Gear Entanglement

Of the factors limiting population growth, vessel strikes and entanglements in fishing gear are the best documented. An average of 2.6 whales incurred serious injury or died from ship strike or entanglement per year between 2005 and 2009 (Waring *et al.* 2011). This is based on inspection of carcasses and is likely a minimum estimate of actual human-caused mortality. It equates to ~0.6% of the total number of North Atlantic Right Whales thought to have been alive in 2010. The results of necropsies conducted on 75 Right Whale carcasses between 1970 and 2007 indicate that 48% (36 individuals) of the deaths were anthropogenic (11% from entanglement and 37% from vessel strikes), 24% (18 individuals) were neonates, and 28% (21 individuals) died from unknown causes (Knowlton and Kraus 2001; Moore *et al.* 2004; Brown *et al.* 2009). Between 1987 and 2006, 25% of all confirmed deaths from vessel strike occurred in Canadian waters (Brown *et al.* 2009).

Of all documented vessel strike mortality, 75% occurred between 1991 and 2007 (Brown *et al.* 2009). This represented half of all known Right Whale deaths for this period. Since 2002, 71% of documented adult Right Whale deaths were caused by vessel strikes and 29% by entanglement—and about one-third of documented calf deaths were attributed to anthropogenic factors (Moore *et al.* 2004). These values likely under-represent total human-related mortality because not all deaths are documented (especially those of entangled whales). For example, the carcasses of chronically entangled whales are more likely to sink because they have less blubber. Demographic modelling suggested that mortality (number of Right Whale deaths per year) increased by 3-5% between 1980 and 1998, and that most of the increase involved adult females (Caswell *et al.* 1999; Fujiwara and Caswell 2001; Moore *et al.* 2007).

Human-caused mortality appears to be higher in females than males (Fujiwara and Caswell 2001). One explanation is that adult females are more vulnerable to human caused mortality such as vessel strikes (e.g., Fig. 8) because they tend to spend more time at the sea surface when lactating and accompanied by a calf, and would therefore be more likely to encounter ship traffic (Baumgartner and Mate 2003). Six of eight whales found dead in 2004 and 2005 were adult females, of which three were carrying near-term fetuses, and one other was sexually mature (Kraus *et al.* 2005). At least four of the dead whales had died as a result of vessel strike or entanglement (Kraus *et al.* 2005). On average, females produce 5.25 offspring during their lifetime—thus the loss of these individuals was equivalent to losing 21 animals (Kraus *et al.* 2005).

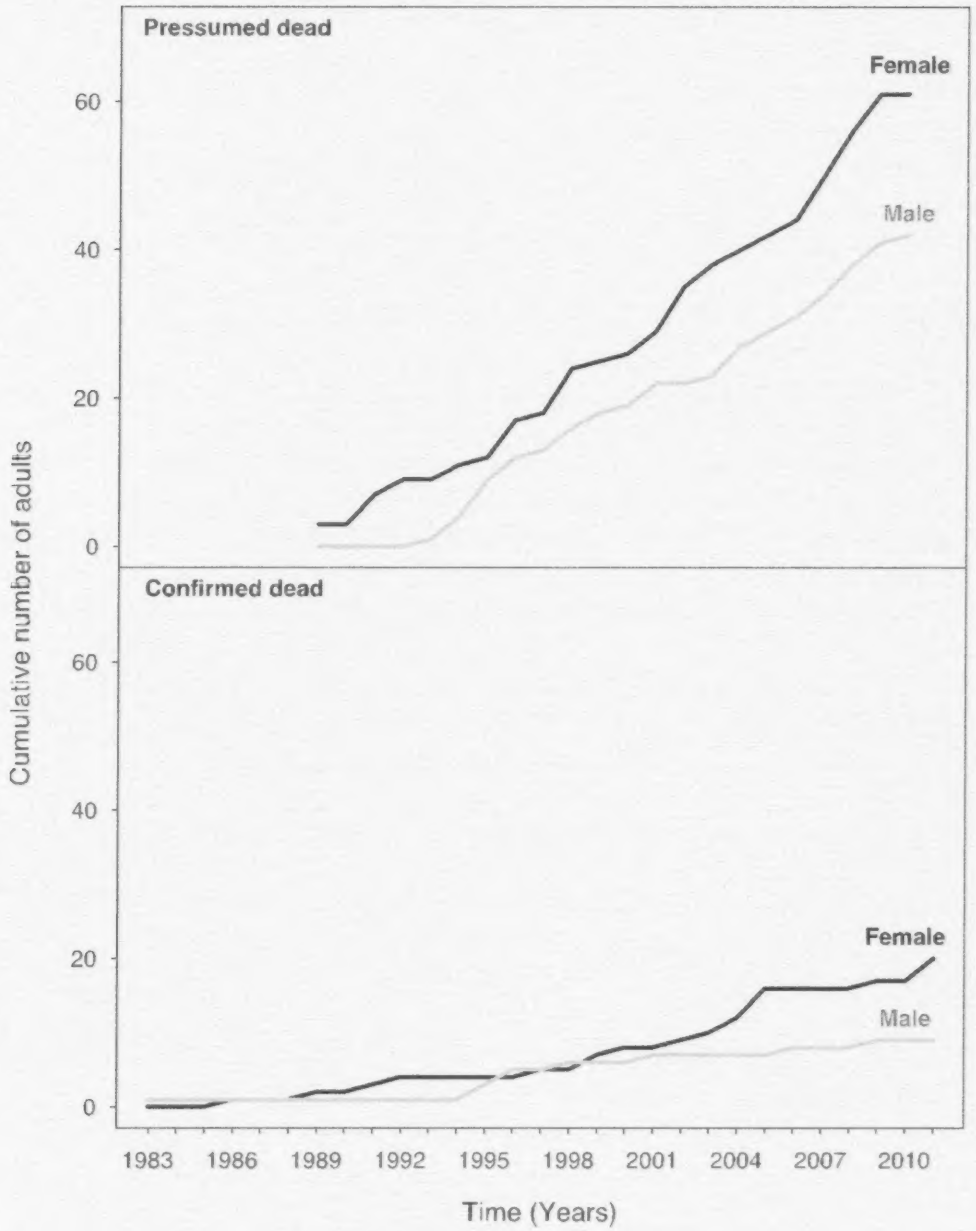

Figure 8. Cumulative number of adult male and female North Atlantic Right Whales presumed dead (according to 6-year rule) and confirmed dead (Right Whale Consortium 2011). This figure demonstrates that in recent years, more adult females are confirmed dead and also that the number of males and females presumed to be dead is considerably higher than the confirmed number.

The risk of anthropogenic mortality is not evenly distributed throughout the range. For example, risk is believed to be lower in areas that have been federally identified as Critical Habitat in Canada or designated as such in the United States. Various conservation measures have been implemented in these areas to mitigate the risk of ship strikes, including slower speeds in the U.S. and shifted shipping lanes in Canada. Furthermore, regulations have been implemented in the U.S. to reduce entanglements in fishing gear. Whales travelling between or spending time outside these specially designated areas are likely at greater risk of being struck or entangled. A petition to revise existing Critical Habitat in the United States to include "migratory habitat" has been under review since 2010 (NMFS 2010).

Vulnerability to Vessel Strike

Vessel strikes are the leading documented cause of mortality in North Atlantic Right Whales (Reeves *et al.* 1978; Kraus *et al.* 2005; Moore *et al.* 2007), and may occur more frequently than necropsy statistics suggest. About 7% of individually known North Atlantic Right Whales have scars or wounds attributable to vessel strikes, although the effects of such injuries on morbidity, productivity and longevity are difficult to estimate (Brown *et al.* 2009).

The majority of lethal and severe vessel strikes, including all large whale species, are caused by large vessels exceeding 80 m in length (Laist *et al.* 2001). Shipping has increased over the past 50 years largely due to expansion of international trade (Waters *et al.* 2000; Hackett 2003), and is predicted to increase at U.S. Atlantic coastal ports from ~47,200 calls in 2000 to ~93,500 calls in 2020 (Hackett 2003; Ward-Geiger *et al.* 2005). Right Whales often encounter ships at the entrances to commercial ports and military bases (Ward-Geiger *et al.* 2005). Lethal vessel strikes have been reported primarily in and near shipping lanes and in coastal areas where Right Whales aggregate (Knowlton and Kraus 2001; Ward-Geiger *et al.* 2005).

The behaviour of Right Whales makes them particularly vulnerable to vessel strikes. Studies of Right Whales carrying multi-sensor acoustic recording tags in the Bay of Fundy showed that they did not respond to vessels or to the sounds of approaching vessels (Nowacek *et al.* 2004; Vanderlaan and Taggart 2007). This suggests that Right Whales are habituated to vessel noise. An experimental study of acoustic signals designed to warn whales and prevent vessel strikes resulted in whales surfacing where the risk of being struck was greatly increased (Nowacek *et al.* 2004). Feeding at the surface also increases the chances of being struck by a vessel. During spring in Cape Cod Bay, Right Whales spend up to 84% of their time feeding in the upper few metres of the water column (0.5 and 2.5 m; Parks *et al.* 2011).

Vessel speed affects the risk of a strike occurring and the severity of resulting injuries (Kite-Powell *et al.* 2007; Vanderlaan and Taggart 2007). Logistic regression models estimated that almost all strikes are lethal when the vessel's speed exceeds 15 knots (Vanderlaan and Taggart 2007). The modelled probabilities of lethal injury are 80% at speeds of 15 knots, and decrease to 20% at 8.6 knots. Achieving a 50% decline in lethal injury requires that speeds be reduced to below 11.8 knots.

Management of Shipping Industry

Measures have been taken by the governments of Canada and the United States to reduce the likelihood and severity of vessel strikes (Kraus *et al.* 2005, Vanderlaan and Taggart 2009). These include designating Right Whale Critical Habitat, establishing mandatory ship-position reporting (adopted by the International Maritime Organization [IMO]; Silber *et al.* 2002), implementing mandatory vessel-routing amendments with IMO traffic separation schemes (TSS) (IMO 2003, 2006), mandatory vessel speed restrictions (NMFS 2008), and recommended "Areas To Be Avoided" (ATBA) (IMO 2007, 2008). Implementation of the ATBA in Roseway Basin is perhaps the most important measure Canada has taken to reduce the risk of lethal vessel strikes to Right Whales (Vanderlaan and Taggart 2009). The ATBA consists of voluntary avoidance of this high-density feeding ground and it is in effect between 1 June and 31 December (IMO 2007; Vanderlaan and Taggart 2009). Although the ATBA is recommendatory and thus not enforced, vessel-operator compliance ranges from 57% to 87% (Vanderlaan and Taggart 2009). This high level of compliance is estimated to have reduced the risk of lethal strikes on Right Whales in Roseway Basin by ~82% (Vanderlaan and Taggart 2009).

Shipping lanes have also been modified to mitigate the risk of vessel strike. In 2003, the 112-km-long shipping lanes extending from the entrance of the Bay of Fundy to the port of Saint John (New Brunswick) were shifted to reduce the overlap between vessels and high densities of feeding Right Whales during the summer and fall (Knowlton and Brown 2007). This measure resulted in longer passage times for vessels, but reduced the likelihood of ship strikes on Right Whales (Knowlton and Brown 2007).

In the United States, the shipping lanes servicing Boston were moved 12° and narrowed by 2.8 km (1.5 nm) (Knowlton and Brown 2007) to avoid aggregations of both Humpback Whales and Right Whales. A recommendatory seasonal ATBA was created in 2009 for ships (300 gross tons or more) in the Great South Channel during times of peak Right Whale residency (NMFS 2011). In addition, recommended shipping routes were established in 2006 for Florida, Georgia, and Massachusetts (NMFS 2006), and mandatory speed restrictions of 10 knots (for vessels 65 feet or longer) were established in Seasonal Management Areas such as the calving grounds (southeastern United States), the migratory corridor (between Florida and Massachusetts), and feeding grounds in the Gulf of Maine (Cape Cod Bay, off Race Point, and Great South Channel; Knowlton and Brown 2007; NMFS 2011). NOAA Fisheries also designates Dynamic Management Areas based on Right Whale sighting data, by announcing voluntary vessel speed-restriction zones in an effort to reduce ship strikes in areas where Right Whales occur.

Despite the conservation measures implemented to reduce the risk of mortality and serious injury from vessel strikes, 10 individuals were observed with new significant vessel strike injuries in 2009-2010 (Hamilton *et al.* 2010; Hamilton and Knowlton 2011). A high-speed ferry between Yarmouth, Nova Scotia, and Portland, Maine, is expected to resume operation after a 5-year hiatus, increasing the risk of strikes on Right Whales.

Vulnerability to Entanglement

North Atlantic Right Whales are vulnerable to entanglement in fishing gear because they inhabit areas of intense fishing activity where high-risk gear is deployed (e.g., pots with buoy lines in the water column and nets with anchored ground lines) (Johnson *et al.* 2007). More than 83% of photo-identified individuals bear evidence of entanglement (Johnson *et al.* 2007; Knowlton *et al.* 2012). Head entanglements can interfere with feeding and lead to starvation, and are more common for Right Whales than other species of baleen whales (Johnson *et al.* 2005). Furthermore, head entanglements are particularly challenging to resolve through disentanglement techniques because rescuers are at greater risk of being struck by the whale's thrashing tail while trying to free the animal (compared to tail entanglements where the rescuers can position themselves well behind the whale's tail).

Although no changes to fishing gear have been mandated in Canada, entanglement risk may be lower in Canadian waters such as the Bay of Fundy than in U.S. waters because of how groundlines are recommended to be set in the Canadian Lobster (*Homarus americanus*) pot fishery (Brillant and Trippel 2010). In 61 entanglement events analyzed (30 involving Humpback Whales and 31 Right Whales), buoy lines and groundlines were the most common types of fishing gear (81%) involved (Johnson *et al.* 2005). In U.S. waters, ropes are typically set 3 m above the sea floor where they pose the greatest risk of entangling whales (Brillant and Trippel 2010). However, in the Bay of Fundy, the ropes lie near the bottom. Nevertheless, entanglements continue to be reported in the Bay of Fundy (Johnson *et al.* 2007). Right Whales are known to forage on the sea floor at depths of ca. 200 m in the Bay of Fundy (Baumgartner *et al.* 2007 p 155) and "are frequently seen with mud on their heads" (Kraus and Rolland 2007, Colour Illustration 8). Right Whale surveys and Canadian fishing-gear deployment data suggest that the Lobster fishery poses the greatest threat to Right Whales during the spring and fall when migration occurs to and from the areas in Canada identified as Critical Habitat (Grand Manan Basin and Roseway Basin; Vanderlaan *et al.* 2011)

The Lobster fishery is not the only fishery in Canada with the risk of entangling Right Whales. The greatest risk of entanglement is from groundfish hook-and-line during the summer when Right Whales reside in the Critical Habitats for several months (Vanderlaan *et al.* 2011). Relative threat of entanglement to Right Whales during summer (July to October) is 42% for the groundfish hook-and-line fishery and only 9.6% for offshore lobster trap fishery (Vanderlaan *et al.* 2011). Based on entanglement scar data from 1993 to 2004, 87 ± 29 incidents of entanglements causing scarring occur annually and there is a ~1% chance each year of a lethal entanglement of a Right Whale occurring in identified Critical Habitat in Canada (Vanderlaan *et al.* 2011).

No management measures have been taken in Canada to reduce the risk of Right Whale entanglement in fishing gear. However, the World Wildlife Fund, for example, developed a voluntary program with fishermen to reduce the amount of fishing line in the water. In addition, DFO and the Grand Manan Fisherman's Association have developed a mitigation plan to reduce interactions with lobster fishing gear.

Management of Fishing Activity in U.S. Waters

In the United States, the Atlantic Large Whale Take Reduction Team developed by NMFS in 1996 created an Atlantic Large Whale Take Reduction Plan (ALWTRP) in 1997 to reduce the level of serious injury and mortality from entanglement in gillnet and trap/pot fisheries (Johnson *et al.* 2007). The ALWTRP was published in the U.S. Federal Register as an Interim Final Rule and the regulations were updated in 1997 and 2000. Three important rules were published by NMFS in 2002 that resulted in additional modifications to commercial fishing gear. These included the creation of a method for temporarily restricting fishing activities in locations where unexpected aggregations of Right Whales are observed (Dynamic Area Management), and the creation of permanently restricted areas determined by the annual, predictable aggregation of Right Whales (Seasonal Area Management). Temporary measures in Seasonal Area Management (e.g., Cape Cod Bay) restrict gear that can be used during times of peak Right Whale abundance. Furthermore, a Final Rule published by NMFS in 2007 increased the size of the Southeast U.S. Restricted Area and prohibited gillnet fishing there during the Right Whale calving season (NMFS 2007).

Entanglement in fishing gear continues despite the recent conservation measures. In 2009 and 2010, 12 Right Whale entanglements were documented (Hamilton *et al.* 2010; Hamilton and Knowlton 2011) and at least three of the whales died. In addition, serious injuries of three previously entangled individuals were reported in 2009 (Hamilton *et al.* 2010; Hamilton and Knowlton 2011).

Other Potential Limiting Factors

Population growth may also be limited by parasites, disease, contaminants, industrial activities, the genetic and demographic effects of small population size, and nutritional stress.

Fecal samples, predominately collected in the Bay of Fundy, have revealed a number of aspects about Right Whale health related to parasites and microbes, hormone metabolites (e.g., reproductive stress hormones), environmental contaminants, and immune proteins of the gut (Rolland *et* al. 2007). Of particular note is that the feces contain two parasites, *Giardia* and *Cryptosporidium*, at much higher levels than found in other marine mammals (Rolland *et al.* 2007). These parasites can cause gastrointestinal disease in humans and terrestrial animals, but their impact on Right Whale health is unknown (Rolland *et al.* 2007). It is unclear whether these organisms were (a) introduced through point sources such as sewage outflows, are (b) specific to particular species of marine mammals, and/or are (c) naturally cycling within the marine environment.

Blubber biopsies from Right Whales contain low levels of endocrine-disrupting chemicals (e.g., dichlorodiphenyltrichloro-ethane [DDT] and polychlorinated biphenyls [PCBs]), which are known to contribute to reproductive dysfunction in some other mammals (Woodley *et al.* 1991; Weisbrod *et al.* 2000; Kraus *et al.* 2007). These fat-soluble contaminants may particularly affect calves that rely on their mother's fat stores while being nursed (Kraus *et al.* 2007). Even low concentrations of these persistent chemicals may affect the early development of reproductive organs and endocrine, immune, and neurological systems (Colborn *et al.* 1993; Rolland *et al.* 1995; Kraus *et al.* 2007). However, the actual effects, if any, of contaminant exposure on North Atlantic Right Whales are unknown.

Low-level pollution, ship traffic, ocean dumping, and dredging have all been identified in recovery plans as factors that degrade Right Whale habitat. However, no studies have yet determined how or how much these factors adversely affect the habitat.

Underwater noise is also a concern. Background noise has intensified in the Bay of Fundy because of increased ship traffic (Parks *et al.* 2011) and may have caused changes in Right Whale calling behaviour (Parks *et al.* 2007b; Parks *et al.* 2011). Ambient noise in the oceans generally has been increasing and has almost certainly made it more difficult for baleen whales to communicate (Clark *et al.* 2009). The effects of acoustic masking (i.e., loss of communication space) by vessel noise is thought to be greater for North Atlantic Right Whales than for other species of baleen whales (e.g., Fin and Humpback Whales) because their calls are not as loud (Clark *et al.* 2009). Right Whales faced with a noisier environment tend to increase the amplitude of their calls to enable continued communication (Parks *et al.* 2011).

Wind and tidal power development may affect Right Whales. Such projects have been proposed in Nantucket Sound and in Rhode Island Sound where Right Whales were observed during the spring of 2010 (Kenney 2010; Leeney *et al.* 2010) and in several other locations along the eastern U.S. where Right Whales may pass nearby during migration. Construction of renewable energy projects may cause physical and acoustic disturbance (including from seismic surveys for site assessments), and increase the risk of vessel strikes (Madsen *et al.* 2006; Leeney *et al.* 2010). There is concern as well that exploration for offshore oil and gas resources is about to begin off the eastern United States, bringing new risks to these whales.

Population growth may also be limited by the quality and quantity of prey. Individuals judged to be in poor body condition were observed between 1991 and 1999 when reproductive output of the Right Whale population was lower than previously (Pettis *et al.* 2004). Changes in blubber thickness in the mid-1990s were correlated with changes in calving intervals and large-scale atmosphere-ocean processes that control prey quality and quantity (Miller *et al.* 2011). Similar linkages have been made between sea surface temperatures and annual calving success of Southern Right Whales (Leaper *et al.* 2006). The NAO is predicted to fluctuate with greater frequency in the future (Greene and Pershing 2004), which could make feeding conditions more variable for North Atlantic Right Whales.

Factors other than prey availability that may also have reduced reproductive performance from 1989 to 2003 include low levels of genetic variability and inbreeding, as well as exposure to pollutants and toxins (Kraus *et al.* 2007). Whether reproductive rates have remained below their potential since 2003 has not been determined. However, annual numbers of calves born during the 2000s has been higher on average than during the 1990s (Fig. 5).

PROTECTION, STATUS, AND RANKS

Legal Protection and Status

Right Whales are protected internationally from commercial whaling by the International Convention for the Regulation of Whaling (ICRW), and from commercial trade by the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES). In the United States, Right Whales benefit from the strong legislative protection of the *Endangered Species Act* (ESA) and the *Marine Mammal Protection Act* (MMPA). The National Marine Fisheries Service (NMFS) is responsible for the conservation of Right Whales in the United States, and published a Recovery Plan in 1991 for both the North Atlantic and North Pacific Right Whales, and a revised plan in 2005 for North Atlantic Right Whales only (NMFS 1991, 2005). This plan identifies threats and outlines actions required to decrease the risk of extinction and increase the prospects for population recovery (NMFS 1991; Brown *et al.* 2009). NMFS publishes annual stock assessment reports on marine mammals, and determines a "potential biological removal" (PBR) level for each stock (recently 0.8 individuals per year; Waring *et al.* 2011).

In Canada, Right Whales are protected by the Marine Mammal Regulations under the *Fisheries Act*, and Fisheries and Oceans Canada (DFO) is the responsible agency for the conservation of Right Whales (e.g., regulating fishing, generating guidelines for whale watching activity in the Bay of Fundy). North Atlantic Right Whales were assessed as Endangered by COSEWIC in 2003 and listed as such under SARA in 2005 (Order Amending Schedules 1 to 3 to the *Species at Risk Act* 2005). In November 2013, COSEWIC re-assessed the status of this species as Endangered.

DFO and World Wildlife Fund Canada jointly published a Canadian Right Whale Recovery Plan in 2000 (Anonymous 2000) and a Canadian Recovery Strategy was subsequently published in 2009 following SARA guidelines (Brown *et al.* 2009). The Recovery Strategy provides justification for designating Grand Manan Basin in the Bay of Fundy and Roseway Basin on the southwestern Scotian Shelf as Critical Habitat under SARA (Brown *et al.* 2009). The interim Recovery Goal is "*to achieve an increasing trend in population abundance over three generations*" by reducing anthropogenic mortality, injury (vessel strikes and entanglements in fishing gear) and disturbance (vessel presence or exposure to contaminants), and by improving knowledge about life history characteristics, low reproductive rates, habitat, and threats to recovery through research, collaboration and development of education and stewardship activities (Brown *et al.* 2009).

Non-Legal Status and Ranks

North Atlantic Right Whales are red-listed as Endangered by IUCN (Reilly *et al.* 2012). According to NatureServe (2001), their global status is G1 and their Rounded Global Status (using the algorithm to evaluate species rank) is G1-Critically Imperiled (last reviewed in 2006), meaning that the species is at a very high risk of extinction due to extremely low numbers and failure to increase significantly even with protection (Table 2). The national status is N1 for both the United States (last reviewed in 1997) and Canada (last reviewed in 2011), meaning that the species is critically imperiled.

Table 2. NatureServe sub-national rankings for North Atlantic Right Whales.

Country	State/Province	Status	Definition
Canada	Labrador	SNR	Unranked
	New Brunswick	S1	Critically Imperiled
	Newfoundland Island	SH	Possibly Extirpated
	Nova Scotia	S1	Critically Imperiled
	Prince Edward Island	SH	Possibly Extirpated
	Quebec	S1	Critically Imperiled
United States	Delaware	SXB	Possibly Extirpated Breeding
	Florida	S1	Critically Imperiled
	Georgia	S1	Critically Imperiled
	Maine	SNR	Unranked
	Maryland	SNA	Unranked
	Massachusetts	S1	Critically Imperiled
	New Jersey	S1	Critically Imperiled
	New York	SNA	Unranked
	North Carolina	SNA	Unranked
	Rhode Island	SU	Unrankable
	Texas	S1	Critically Imperiled

Habitat Protection and Ownership

Important habitat for North Atlantic Right Whale foraging and calving has been protected in Canadian and U.S. waters. In Canada, DFO has identified two Critical Habitat areas—Grand Manan Basin in the lower Bay of Fundy and Roseway Basin on the southwestern Scotian Shelf (Brown *et al.* 2009) (Fig. 3). In the United States, NMFS has designated three Critical Habitat areas: Cape Cod Bay, the Great South Channel, and the coastal waters of the southeastern United States from Brunswick, Georgia to Jacksonville, Florida, out to 15 nautical miles offshore, and from Jacksonville to Sebastian Inlet, Florida, out to 5 nautical miles from shore (NMFS 1994) (Fig. 3). Special protection of migratory habitat is being considered in the United States (NMFS 2010).

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- Annie Levesque, Biologiste en conservation, Ministère des Ressources naturelles, Direction de l'expertise sur la faune et ses habitats, Québec

Department of Fisheries and Oceans

- David Millar, Chair, Canadian Recovery Network for the North Atlantic Right Whale, Nova Scotia

Conservation Data Centres

- S. Blaney, Atlantic Canada Conservation Centre, Sackville, New Brunswick
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Wildlife Management Boards

- Marck O'Connor, Director of Wildlife Management, Nunavik Marine Region Wildlife Board, Inukjuak, Quebec
- Adamie Padlayat, Executive Director, Nunavik Marine Region Wildlife Board, Inukjuak, Quebec

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BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Sarah M.E. Fortune is a PhD candidate at the University of British Columbia. She is studying the foraging ecology of Bowhead Whales and North Atlantic Right Whales. Sarah previously worked for the North Atlantic Right Whale Habitat Program (C. Mayo) at the Provincetown Center for Coastal Studies where she studied the foraging ecology of Right Whales in Cape Cod Bay. She completed her Master's research at UBC on the growth and energetics of North Atlantic Right Whales, and studied marine mammal energetics as a Research Assistant in the Marine Mammal Research Unit. Sarah is continuing her collaborations with researchers from the New England Aquarium, Woods Hole Oceanographic Institution, Provincetown Center for Coastal Studies, and Northwest Fisheries Science Center.

Dr. Andrew W. Trites is a Professor and Director of the Marine Mammal Unit at the UBC Fisheries Centre, and is Research Director of the North Pacific Universities Marine Mammal Research Consortium. He is also a Research Associate at the Vancouver Aquarium, a member of the Marine Mammal Specialist Group for the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and a member of the PICES Advisory Panel on Marine Birds and Mammals. Dr. Trites has been studying marine mammals in the North Pacific for over 30 years. His research involves captive studies, field studies and simulation modelling. He trains students and collaborates with researchers specializing in other disciplines such as nutrition, ecology, physiology, anthropology and oceanography.

COLLECTIONS EXAMINED

The North Atlantic Right Whale sighting and identification databases (Right Whale Consortium 2011) were accessed to prepare this report. Major contributors to these databases were: Blue Ocean Society, Fish and Wildlife Research Institute, Georgia Department of Natural Resources, New England Aquarium, Northeast Fisheries Science Center, Provincetown Center for Coastal Studies, University of North Carolina Wilmington, Whale Center of New England, and Wildlife Trust. The sightings database is achieved at the University of Rhode Island (R. Kenney) and the identification database is archived at the New England Aquarium (P. Hamilton). Where necessary, reference in the report to this collection of unpublished data is given as (Right Whale Consortium 2011)".

PERSONAL COMMUNICATIONS

Previous COSEWIC status reports:

Natalie Cadet—Observations Littoral Percé
Philip Clapham—NMFS, Northeast Science Center
Robert Michaud—Groupe de recherche sur les mammifères marins
Rosaline Rolland—New England Aquarium
Richard Sears—Mingan Island Cetacean Society
Bradley White—Natural Resources and DNA Profiling and Forensic Centre, Trent University

Current COSEWIC status report:

Veronique de la Chenelière—Groupe de recherche et d'éducation sur les mammifères marins
Robert Kenney—University of Rhode Island

Appendix 1. IUCN Threats Assessment Data

Species or Ecosystem Scientific Name	North Atlantic Right Whale
Element ID	**Elcode**

Overall Threat Impact Calculation Help:

Threat Impact		Level 1 Threat Impact Counts: high range	low range
A	Very High	0	0
B	High	0	0
C	Medium	0	0
D	Low	4	4
	Calculated Overall Threat Impact:	Medium	Medium
	Assigned Overall Threat Impact:		
	Impact Adjustment Reasons:		
	Overall Threat Comments		
	Impact Adjustment Reasons:		

	Threat	Impact		Scope	Severity	Timing	Comments
1	Residential & commercial development						
1.1	Housing & urban areas						
1.2	Commercial & industrial areas						
1.3	Tourism & recreation areas						
2	Agriculture & aquaculture						
2.1	Annual & perennial non-timber crops						
2.2	Wood & pulp plantations						
2.3	Livestock farming & ranching						
2.4	Marine & freshwater aquaculture						
3	Energy production & mining		Impact	Unknown	Unknown	High	
3.1	Oil & gas drilling			Restricted	Unknown	High	
3.2	Mining & quarrying						
3.3	Renewable energy			Restricted	Unknown	High	
4	Transportation & service corridors	D	Low	Pervasive - Large	Slight	High	
4.1	Roads & railroads						
4.2	Utility & service lines						

	Threat	Impact		Scope	Severity	Timing	Comments
4.3	Shipping lanes	D	Low	Pervasive - Large	Slight	High	Virtually all of the individuals pass through shipping lanes on migration. 1.6 animals die or have serious injuries each year (1.2 US and 0.4 Canadian waters). This is <1% of the population (i.e., 0.35%). Extending the mortality over the next 10 years means a total loss of 16 individuals (3.5% of the 449 non calves alive in 2010).
4.4	Flight paths						
5	Biological resource use	D	Low	Pervasive - Large	Slight	High	
5.1	Hunting & collecting terrestrial animals						
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting						
5.4	Fishing & harvesting aquatic resources	D	Low	Pervasive - Large	Slight	High	~1 animal dies or is seriously injured per year by fishing gear (0.4 US and 0.6 Canadian waters). This represents <1% of the population (0.22% of 2010 population). 10 animals would die over the next 10 years, which is equal to ~2.2% of the current population.
6	Human intrusions & disturbance	D	Low	Pervasive	Slight	High	
6.1	Recreational activities	D	Low	Pervasive	Slight	High	Recreational boater strikes are likely an issue for this species, as is whale watching in Canada.
6.2	War, civil unrest & military exercises						Military exercises may be an issue, no published data.
6.3	Work & other activities	D	Low	Pervasive	Slight	High	The impact of researchers has been raised as a concern. There is a single record of a ship strike from a research vessel, but not while conducting research.
7	Natural system modifications						
7.1	Fire & fire suppression						
7.2	Dams & water management/use						
7.3	Other ecosystem modifications						
8	Invasive & other problematic species & genes			Unknown	Unknown	Unknown	

	Threat	Impact		Scope	Severity	Timing	Comments
8.1	Invasive non-native/alien species			Unknown	Unknown	Unknown	May be an issue but no data are available.
8.2	Problematic native species						
8.3	Introduced genetic material						
9	Pollution			Pervasive	Unknown	High	
9.1	Household sewage & urban waste water			Pervasive	Unknown	High	May be an issue but no data.
9.2	Industrial & military effluents			Unknown	Unknown	High	Contaminants in blubber but effects unknown.
9.3	Agricultural & forestry effluents						
9.4	Garbage & solid waste			Unknown	Unknown	Unknown	
9.5	Air-borne pollutants			Pervasive	Unknown	Unknown	Boat and motorized vehicle engine fumes may be a problem but no data available.
9.6	Excess energy						
10	Geological events						
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides						
11	Climate change & severe weather	D	Low	Pervasive	Slight	High	
11.1	Habitat shifting & alteration						
11.2	Droughts						
11.3	Temperature extremes	D	Low	Pervasive	Slight	High	Temperature fluctuations are likely to impact prey base and positive and negative changes are predicted for the future.
11.4	Storms & flooding						

Classification of Threats adopted from IUCN-CMP, Salafsky *et al.* (2008).